Firm-Customer Relationship Efficiency

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Firm-Customer Relationship Efficiency (FCRE) measures the performance of the retention function at the customer level from a productivity perspective. The efficiency measurement aids in the allocation of resources to improve the performance of the retention function. Existing methods to evaluate retention efforts exclude resources expressed in non-monetary terms like quality despite the growing importance for the maintenance of the firm-customer relationship. Retention operation is assumed to be a production process during which the firm and the customer exchange resources through a black box. The efficiency of this transformation is measured using benchmarking against a frontier of best or efficient practices. DEA is applied to construct it. A set of models is built to measure performance losses, which are attributed to the negative effect on revenue from overinvestment, waste of resources and unutilized sales potential. We built on the concepts of congestion, technical inefficiency and slacks to measure these respectively. The analysis also contributes to improved performance by investing on efficient customers, reducing waste gradually and setting minimum expected sales target by identifying worst performers. It is also shown how FCRE can be included in CRM tasks like identifying customer segments and churn modelling.

The FCRE concept was applied on an online service with a subscription business model. The congestion model was modified to identify congestion in one input. The waste model was solved to identify total waste and sales increase potential. We applied further on the waste model layering technique to get more feasible targets for efficiency improvement and the worst practice frontier concept to identify worst performers. In order for the efficiency scores to be used for managerial purposes, we investigated the relationship between the efficiency scores and customer information. We find that FCRE can be used to identify customer segments and in signalling churn.

Keywords: customer retention, marketing efficiency, resources allocation, marketing performance

Dedication

To my family and friends

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1 Introduction

As Marketing evolves over time, a lot of attention has been drawn on the relationship between the firm and the customer in order to help the firm grow (Kotler 1991). Efforts that result in acquiring customers and retaining them in the long run are key to turning a marketing strategy into a success (Petersen et al. 2009). That is why firms seek to establish, maintain and develop relationships with their customers through Relationship Marketing (RM) activities (Berry et al. 1983). Until recently there seems to be no consensus on the definition of RM (Agariya and Singh 2011). Still there are practices that stem out of RM that help in the maintenance and growth of firm-customer relationships. These practices focus either on acquisition or retention (Nykamp 2001). Sheth and Parvatiyar (1995) first studied RM in consumer markets and suggested fostering relationships with the customers so that the marketing practice becomes more productive. For this reason they suggest that the firm allows the customers to be involved in the product/service design, development and sales functions of the firm following a one to one marketing approach. They also suggested that the firms take advantage of technology and flexible manufacturing techniques for mass customization. The reason is that it is conceptualized that the longer the customers stay with the firm, the higher the profits (Morgan and Hunt 1994, Sheth and Parvatiyar 1995, Bendapudi and Berry 1997).

Apart from RM, another important part of the business strategy that affects the firm-customer relationship and hence the firm's profits is quality of goods and services (Golder et al. 2012). Quality initially referred to manufacturing goods using objective measures (Powell 1995). In the context of services marketing, quality refers to the customer's perception of quality (Parasuraman et al. 1985, Cronin and Taylor 1992). Despite recent research evidence that there is no universally accepted definition or conceptual model of quality[1] (Golder et al. 2012), there is empirical evidence that an organization's financial performance has a positive relationship with the perceived quality of its goods or services (Ghobadian et al. 1994, Rust et al. 1995).

[1] Not just in all relevant academic fields but also within the marketing literature that is of interest in this study

From a decision-making perspective, marketing teams are asked by senior management and shareholders to link their decisions to improving the firm's financial performance (Morgan et al. 2002). Marketing costs have been taking a noticeable proportion of a firm's budget (Foster and Gupta 1994, Stewart 2009). Marketers need to back up their suggestions and decisions on marketing investment as this type of expenditure is prioritized for budget cuts when funds are not available (Weber 2002). Marketing practitioners and academics have long supported the notion of marketing investments[2] at a decision-making level by trying to make these accountable (Kotler 1977, Herremans and Ryans Jr 1995). In the face of this need, researchers have developed empirical models that help decision-making in marketing tasks that have gone under the discipline of Marketing Science[3]. At an operational level, there are metrics that are available for management to consult (Petersen et al. 2009). The systematic approach to evaluating the effect of marketing at a decision making level has led to the development of marketing performance assessment systems (Morgan et al. 2002), which incorporates marketing performance measurement systems that feed management with the appropriate information through these metrics (Jaworski 1988). The goal of these systems is to evaluate marketing productivity in making the best use of the available resources and marketing effectiveness as in choosing the right tactics (Morgan et al. 2002, Sheth and Sisodia 2002).

When it comes to deciding on customer retention investment, appropriate metrics are put in use as managers are asked to allocate firm's resources on tasks such as catalogue mailing (Gönül and Hofstede 2006), loyalty programs (Uncles et al. 2003) or targeted promotions (Paul and Nada 2001), which can be called Relationship Marketing Instruments (RMIs) (Verhoef 2003).These decisions can be made either at the segment level (Zeithaml et al. 2001) or at the individual level (Bhatnagar et al. 2007). As an example of better allocation of resources on retention, Reinartz and Kumar

[2] As opposed to marketing expenditure

[3] Indicative developments in Marketing Science include: advertising elasticity for setting advertising budget (Rasmussen 1952), the Bass model on new product diffusion (Bass 1969), the use of conjoint analysis for creating new products (Green and Wind 1975) and many more including modelling of retention efforts (Neslin et al. 2006).

Reinartz and Kumar (2003) refer to the case of AT&T in 1994 that before analysing relationships and acting upon retaining customers, it was losing millions by focusing solely on acquiring customers using a mass marketing strategy. By reallocating more of their resources on retention efforts, profits were reportedly increased. Another empirical study shows increase in profits by a higher proportion than that of the retention efforts in online services (Feinberg and Kadam 2002). The aforementioned effect of retention effort on firm's performance is of particular importance for the current research.

Marketing decisions on quality improvement are made based on customers' perceptions (Seth et al. 2005). Staff training programs, service process redesign among others are suggested to improve dimensions of the service based on the level of satisfaction and the importance in the customers' evaluation of service quality (Gounaris et al. 2003, Zaibaf et al. 2013, Lai 2014). Although quality is considered crucial for the firm's survival and growth, investing on improving quality too much and it can be disastrous financially because of diminishing returns in revenue (Evans 2005). In Marketing literature service quality is considered an output of the customers' evaluation of quality delivered to them, but Golder et al. (2012) also identify the quality production process that is run by the firm. During the quality production process, the management team makes decisions on quality at a more granular level as in the design of a specific service attribute. They find this concept missing from service quality modelling since it is conceptualized only as an output of the customer's evaluation of the firm's service. Taking into account that firms do allocate resources on quality issues, evaluating and improving relevant decision making requires more careful attention. The concept of return on quality has also been developed and measured at the firm level assuming that all quality improvement efforts are financially accountable (Rust et al. 1995). From the operational research discipline there are studies that provide a more hands-on approach on improving overall service quality by suggesting appropriate allocation of resources (Thanassoulis et al. 1995, Athanassopoulos 1997, Soteriou and Stavrinides 2000). In the context of the firm-customer relationship, this means that the firm can influence the retention of the relationship by producing quality in the form of attributes. This process is then part of the retention effort and in the current

research is considered to operate alongside loyalty programs and other traditional relationship marketing instruments as mentioned before.

The investigation of the effect of marketing investment from the organisation-wide view needs to be driven at a disaggregate level to get better insights as research suggests (Morgan et al. 2002, Sheth and Sisodia 2002). For the firm to offer the same high levels of quality to all customers is infeasible due to limited resources (Garland 2005), so allocating these appropriately is of managerial importance. Zeithaml et al. (2001) suggest that customers with higher profit for the firm weigh certain quality dimensions differently than others with lower profit. They propose that segmenting the customer base not just by traditional characteristics (like demographics) but also by profitability, a better return on the marketing effort on quality can be obtained. On the RM activities side, the effect of RMIs on customer profits has been researched at the segment (Berger et al. 2003) and at the individual level (Venkatesan and Kumar 2004) suggesting that these activities do increase customer profits with a different effect on each being possible. Relevant decision making on allocation of quality-related resources and relationship marketing-related resources can benefit by capturing these different effects across customers. For this reason, this research is focused on supporting decision making at the customer level.

By examining relevant literature, supporting evidence is found that quality and RM activities targeting customer retention have a positive effect on customer profits. Academics have created models that optimize the retention resources even at the customer level and models that help firms allocate resources for quality improvement at the firm or branch level. Although quality is traditionally conceptualized and measured based on the customers' perceptions for the service overall, management teams are still expected to make decisions on quality issues. Quality is produced for their customers through some process but an investigation at the customer level should be conducted as an overall quality improvement may affect the retention of each customer differently. **So, there is a need for the firm to make decisions on allocating its finite resources on relationship marketing and quality at the customer level for retention purposes taking these into consideration simultaneously.**

The allocation of resources can be evaluated either from the perspective of cost-cutting or from the perspective of sales growth (Grönroos and Ojasalo 2004). These two perspectives of the firm's resources assume these are tangible as in "value recognised in the balance sheet" (Barry et al. 2005). The quality production process is used to create attributes of goods or services that are not necessarily tangible and financially accountable (Parasuraman et al. 1985, Cronin and Taylor 1992). This means that in order to help the firm allocate its resources on retention activities and quality both tangible and intangible resources need to be incorporated. The decision making is suggested to take place at the customer level when evaluating marketing efforts (Sheth and Sisodia 2002). However, as mentioned earlier only RMIs have been modelled at the customer level while quality-related resources have not. The quality dimension in non-financial terms has not been found in resources allocation models at the customer level. The inclusion of quality is deemed necessary for decision makers as it is found to play a rather important role in relationship growth and firm's financial performance.

In this thesis, we propose a model to help firms decide on allocating their resources, whether tangible or intangible, on the customer level while simultaneously focusing on relationship marketing and quality efforts that drive customer retention and hence the firm's financial performance. We take into consideration that any decision making model should include the customers' value and the multiple facets of quality that depend on the industry and the firm. This means that units of measurement will be different from each other. Based on these needs we propose to take an approach on retention-related optimal allocation of resources that comes from Operational Research and more specifically efficiency measurement as done by Thanassoulis et al.(1995), Athanassopoulos (1997), and Soteriou and Stavrinides (2000), who tackled the issue of quality from an operational approach. This study is combining developments in marketing theory on firm-customer relationships on the one hand and efficiency measurement theory on the other with practice derived from industrial economics that is also adopted and developed under the Operational Research discipline. Marketing provides the concept of the firm-customer relationship and

Operational Research provides the methodology, the main aim of which is to generate a data-driven support for optimal allocation of resources at the customer level.

1.1 Objectives of the study

This study focuses on measuring the efficiency of the retention function. It assumes a black box process for the firm's resources transforming into customer's purchases. This exchange is necessary for retaining their relationship. This efficiency analysis enriches the information of the customers' lifetimes to the managers. The information can be used for relationship growth opportunities through managing the resources allocation on each customer. There is a need then, to let the managerial teams know how their investments on each customer can be allocated so as to increase return. Since these resources come in various types not just monetary, we pursue a solution in the productivity analysis literature. The concept of a performance measurement framework that is based on the efficiency of the retention function is introduced in this study for this particular purpose.

The objectives of this study are to:

- Develop a conceptual model that shows that the relationship between the firm and the customer can be considered as an exchange of resources that works as an input-output process.
- Introduce appropriate models that measure the efficiency with which the firm's resources are transformed into customer's resources and vice versa.
- Show empirically that this concept is useful for practicing managers to allocate retention-related resources for retention more productively and to build upon the concept to make further improvements in their CRM tasks, which is also of particular interest for academic communities.

1.2 Thesis Structure

The thesis contains seven chapters. The purpose of the first (current) chapter was to introduce the reader to the problem and the main theme of the research. The second chapter covers the part of the marketing literature that refers to firm-customer relationships and the firm's effort to retain these. The third chapter is an introduction to performance measurement under both the marketing and economics perspective. The fourth chapter introduces and develops the main concept of this research and presents the models to support it. Chapter five shows empirically how the concept is applied in a real-life business case and presents the findings. Chapter six includes further analysis for CRM purposes based on the efficiency findings. The last chapter includes summary of the research, discussion, its limitations and proposed future work.

2 Marketing and the firm-customer relationship

Marketing has been defined in various ways over the years. Kotler et al (2005) define marketing as '*satisfying needs and wants through an exchange process*[4]'. The exchange refers to resources that can be economic, social or psychological (Bagozzi 1979). In the firm-customer relationship context, although the exchange was observed through the sales transaction (Coviello et al. 1997), it now serves the goal of forming and maintaining relationships (Berry et al. 1983). The customer is involved in advertising the brand, spreading the word, giving feedback in the form of complaint or suggestion and is helping the firm and its brand(s) to move forward and evolve (McKenna 1991). In practice, relevant research has shown firms to use customer databases to design and implement promotional schemes (Bickert 1992) or to organize festivities for their customers (Bhattacharya and Bolton 2000). The formation, maintenance and growth of the relationship between the firm and the customer during which these resources are being exchanged is the key focus of Relationship Marketing (RM) (Berry et al. 1983). The fact that firms started to focus on the customer created new marketing needs that set, according to Kotler (1991), RM to be a paradigm shift for Marketing about 25 years ago.

A relationship that goes beyond the typical sales transaction is found to be of strategic importance to the firm (Parvatiyar and Sheth 2000). Through practices based on RM, customer retention is found to increase which in turn has a positive effect on firm's finances (Zeithaml et al. 2001). In time, firms have come up with these Relationship Marketing Instruments (RMIs) like rewarding usage or communicating tailored messages and promotions or executing one-to-one marketing strategies so as to maintain and develop their relationships with the customers (Peppers and Rogers 1993, Reichheld 1996b, Bolton et al. 2004). In addition to RMIs, there is also quality that affects customer retention (Athanassopoulos et al. 2001). Indicatively, there is supporting evidence that banks benefit by treating high value customers with superior service (Walsh et al. 2004). Quality efforts and RMIs

[4] This exchange process has been outlined by many academics over the years

like loyalty programs (Bhattacharya and Bolton 2000) and direct communications[5] (Bolton et al. 2004) can be optimized in the marketing management decision process. This research aims at helping in this part of the decision process.

As stated in Chapter 1, there is no widely accepted definition of RM yet (Agariya and Singh 2011). The definition of Parvatiyar and Sheth (2000) is "*the on-going process of engaging in cooperative and collaborative activities and programs with immediate and end-user customers to create or enhance mutual economic value at reduced cost*". This definition gives RM three major attributes. The first one has to do with the purpose which is "*to create or enhance mutual economic value at reduced cost*". The second one refers to the members of this relationship. These are not only the customers that include individuals and businesses but are also the partners of the firm in the operation process, like distributors and/or resellers. The last attribute of the RM definition consists of the actions that target the members of the relationship. The purpose of RM is then to facilitate acquiring or retaining customers. This research is interested in the retention part of RM because of its larger effect on firm's financial performance (Reichheld and Sasser 1990). A small increase in retention efforts can increase the firm's profits by a bigger proportion (Fornell and Wernerfelt 1988). So, from this definition we are focusing on those marketing actions that help in this ongoing retention effort with the customers.

Some findings from the RM research are of particular interest for this study. First, there is the principle of the exchange of resources (Parvatiyar and Sheth 2000). Second, the finding that the formation, maintenance and growth of the firm-customer relationship is of strategic importance for the firm's growth (Berry et al. 1983). Third, there is the necessity for relevant actions on behalf of the firm to benefit from RM (Bhatnagar et al. 2007). Last there is the finding that for the firm-customer relationship to exist it must be mutually beneficiary (Foxall 1999). Firm's marketers and executives are asked to manage relationships because of its strategic importance to the growth of the

[5] As it will be shown in 2.2 we focus on those communications that facilitate relationship building as opposed to short-term sales increase through promotions (e.g. price discounts)

business (Gupta and Lehmann 2003). The economic nature of the relationship shows **a mutually beneficiary value-based exchange of resources between the firm and the customer**[6]. This research tries to help in the decision making process on the exchange of these finite resources.

The strategic importance of the firm-customer relationship for the firm's financial performance requires a structured theory that RM represents. So far a short argumentation on the importance of RM and subsequent efforts has been made. What follows is the theoretical background on customer retention. Then, it is explained how the firm influences customer retention using RM practices. These include quality improvement efforts and RMIs like firm-to-customer communication and loyalty reward programs. It will be explained how retention efforts affect the firm-customer relationship that in turn is linked to the firm's financial performance through customer behaviours of repeat purchase and cross-buying. The goal of this chapter is to explain, through the relevant research in the area, how the firm influences its relationships with customers and how decisions on allocating relevant resources are supported from the metrics currently in use.

2.1 Customer Retention

The application of RM principles on managing firm-customer relationships increases retention, which has an impact on the firm's financial performance (Reichheld and Sasser 1990, Gupta and Zeithaml 2006). The firm benefits from retaining its relationships because the longer the duration, the higher the chances of repeat and multi-product purchases, the lower the costs of serving, the higher the chance of sharing positive word-of-mouth and the harder to switch to a competitor (Rose 1990, Bhattacharya and Bolton 2000). The customer benefits from prolonging her relationship with the firm as the longer she stays, the lower the search costs, the higher the product/service customization level and in general the lower her perceived risk of the partnership (Sheth and Parvatiyar 1995). So, there are benefits for both parties to remain engaged in the relationship.

[6] The firm forms relationships with other market stakeholders as well. For more information please see Payne (2000)

In research and practice a customer is considered retained through various behaviours. Signs of retention like purchasing, cross-buying, recommending the service, or participating in the firm's processes have been used (Bhattacharya and Bolton 2000). We assume a customer is retained in the relationship when she repurchases and cross-buys. These behaviours have a direct effect on the firm's bottom-line. Therefore, we target on these as opposed for example to word-of-mouth. Marketing activities and quality affect these behaviours as is shown later on by affecting the customers' emotion of satisfaction and the attitude of loyalty. The conceptual and structural association of customer's repeat purchases and cross-buying to satisfaction and loyalty is out of the scope of this research. For completeness though, there is short information provided based on relevant research. This way we support our conceptualization of customer retention as beginning with marketing activities and quality from the firm's side and ending with repeat purchases, cross-buying from the customer's side.

Satisfaction is found to have a strong and positive relationship to profits as outcome (Zeithaml et al. 2001, Gupta and Zeithaml 2006). Satisfaction is a person's feelings of pleasure or disappointment resulting from comparing a product's perceived performance (or outcome) in relation to her expectations (Parasuraman et al. 1988, Fournier and Glenmick 1999). If the performance falls short of expectations, the customer is dissatisfied. If the performance matches the expectations, the customer is satisfied. If the performance exceeds expectations, the customer is highly satisfied or delighted. Satisfaction is positively correlated with the customer's estimation of the long term future value of the relationship, which keeps the customer engaged and repurchasing (Bhattacharya and Bolton 2000). Changes in satisfaction levels affect cross-buying as well (Verhoef et al. 2002). These findings set satisfaction as a priority for the marketing team.

The firm can affect the customers' repurchases and cross-buying by influencing the emotion of satisfaction. The customer's judgement of the overall quality affects satisfaction (Athanassopoulos et al. 2001, Golder et al. 2012). Loyalty reward programs also affect satisfaction (Lemon and Wangenheim 2009). Direct communication to the customer affects cross-buying and repeat purchases through its effect on satisfaction (Bolton et al. 2004). In short, quality improvement and

marketing activities like loyalty reward programs and direct communication to the customer, through satisfaction, affect repeat purchases and cross-buying and hence customer retention.

In conclusion, we are interested in the firm's actions that enhance the customer's perception of quality as well as those actions that reward loyalty and facilitate communications, because in the end these lead to repeat purchases and cross-buying hence higher financial performance for the firm. Quality improvement programs increase satisfaction that increases customer retention and cross-buying. Loyalty programs and direct communications affect cross-buying and satisfaction. Marketing and Quality efforts are explored in details the following two sections.

2.2 Marketing activities

As firms understand the importance of customer retention on their financial performance, there have been efforts from their part to try and influence the customer's decision to maintain and grow her relationship with the firm. For instance, the US car brand "Saturn" organized a picnic festival for 700,000 of its customers in order to create stronger bonds with them (Aaker 1994). Tesco's loyalty card launched in the UK aims at rewarding frequent purchases (Livingston and Schober 1995). One can find similar purchase reward programs in many retailers, airlines and other industries all focusing on retaining customers (Bhatnagar et al. 2007).

Marketing activities are either targeting on short-term or long-term effects (McDonald 1998). Short-term marketing activities include for example price discounts or quantity-based promotions and aim at benefiting the customer economically (Bolton et al. 2004). Long-term marketing activities include loyalty reward programs and communication efforts (e.g. catalogue mail) that benefit the customer either economically or socially, immediately or later in time (Berry 1995, Roberts and Berger 1999, Bolton et al. 2004). These long-term marketing activities or RMIs are specifically aimed at facilitating the relationship (Verhoef 2003). Short-term marketing activities, like coupons for immediate discount, have not been found to have an effect on repeat purchase or cross-buying in a relationship context (Gupta and Zeithaml 2006) and so they are not further considered in the thesis. Long-term marketing activities are found to have a positive effect on repeat

purchases and cross-buying (Bolton et al. 2000, Reinartz and Kumar 2003). However, contacting customers for retention too much has been found to have a negative effect on purchases (Fournier et al. 1998, Venkatesan and Kumar 2004). These marketing activities require resources that are finite and it is to the firm's benefit to allocate these for a higher return (Rust et al. 2004). Long-term marketing activities are seen as one important component of the firm's effort to influence customer retention. The other one is Quality.

2.3 Quality

Quality of goods or services has an effect on retention that has been established repeatedly (Reichheld and Sasser 1990, Fornell 1992, Fornell et al. 1996, Golder et al. 2012). A positive relationship between quality and profits is reported for both manufacturing and services (Buzzell and Gale 1987, Rust et al. 1995). Research suggests that quality improvement efforts increase customer satisfaction that affect behavioural intentions, the impact of which is related to improved profitability (Zeithaml et al. 2001). Firms have made investments in human resources function and technology as part of quality improvement programs (Simester et al. 2000). E-services firms are advised to allocate resources to improve the level of security and the websites' ease of use (Lee and Lin 2005). Internet Service Providers should invest in their network's infrastructure quality and advancement as overall network quality affects service quality (Lin and Ding 2005). Healthcare firms are advised to train their nurses and give them a vision on what service excellence is (Tsai and Tang 2008). Hospitality firms are advised to train customer-facing personnel and encourage cultural activities for the customers in order to increase service quality (Zaibaf et al. 2013).

The aforementioned quality improvement suggestions come from academic research in the marketing discipline and especially the services domain. Researchers in marketing literature examine quality from the perspective of the customer and a great focus has been laid on the services context (Seth et al. 2005, Golder et al. 2012). The service quality models have been conceptualized under the assumption that the customer's perception of quality is what interests the firm (Seth et al. 2005). The customer's perception of quality is found to affect her satisfaction as discussed in section

2.1. Service quality (SQ) and customer satisfaction have been used interchangeably at times (Athanassopoulos et al. 2001). The customer is assumed to shape her opinion on service quality based on certain dimensions. For example, SERVQUAL as a customer satisfaction measurement method identifies the dimensions of reliability, responsiveness, assurance, empathy and tangibles (Zeithaml et al. 1996). SQ is measured using data collected through interviews and questionnaires as these are self-reported. The end result is suggestions on improving certain (or all) dimensions. These suggestions however lack a practical guideline of improvement as these are based on the customers' opinion and are often generic.

The perception of quality from the customer's perspective is based on her evaluation of the experience of the good or service. However, this is just one view of quality. Golder et al. (2012) provide their framework, according to which the firm produces and delivers quality attributes that in turn are experienced and evaluated by the customer. These attributes can be universal or customer specific. These attributes can be measured through objective tools or based on customers' perceptions. The firm ideally receives feedback and acts according to goals and resources. When it comes to universal attributes whether these are objectively measured or not as for example the image of the offices or the website design and its usability or even the temperature of the coffee served are limited by the firm. When it comes to customer specific attributes that can be objectively measured like the skill of an employee (customer service agent or salesperson) or the speed of solving a problem then the firm has room for customer-specific decision making. Assuming that not all salespeople are equally skilled then the firm's decision to assign its salespeople to its customers will affect satisfaction (Crosby et al. 1990). This is an example of how the quality delivered cannot be at the highest standard for all customers due to limited resources. Also, relevant efforts across the whole customer base will not have the same effect on all customers (Zeithaml et al. 2001). Therefore, the firm's effort on quality so as to influence retention is actually produced and delivered at the customer level in the form of good/service quality attribute. We are interested to see the effect on retention from that perspective along with the marketing actions.

2.4 Resources Allocation for Customer Retention

Customer retention is an important objective for the firm's marketing function and models that allocate the resources needed are used to improve marketing performance (Bhatnagar et al. 2007, Petersen et al. 2009). Marketing performance measurement was developed as a need to support investment in marketing in the organization's strategy planning and evaluation (Rust et al. 2004). Today's technology and the focus on building relationships with customers have given managers a variety of metrics that help in making decisions not just for customer retention purposes (Rust et al. 2004, Farris 2006). The effect of RMIs like loyalty reward programs and catalogue mailings on firm's profit have been measured through metrics such as Probability of Retention and Customer Lifetime Value (CLV) (Gupta and Zeithaml 2006), while the effect of quality improvements has been linked to firm's financial performance through Return on Quality (ROQ) and customer satisfaction measures (Rust et al. 1995).

The probability of retention, which is the probability that a customer will remain active and continue to purchase the service or good, is an important metric of relationship marketing effectiveness. There are two perspectives to study this probability. First, there is the technical part that aims at estimating the probability and second comes the way it is utilized managerially. The concept of customer retention and how this is influenced by the firm's marketing actions is briefly explained in previous sections. Regarding the analytical process there is a wide selection of techniques used to predict churn in the literature like decision trees, statistical regression and neural networks (Hadden et al. 2005). In a churn prediction tournament, a number of models failed because researchers focused more on explaining the behaviour rather than predicting it, which showed that the chosen technique plays an important role even if the model does not align theoretically with each application (Neslin et al. 2006). When it comes to its use in marketing management, the probability of churn is used to alert for customers about to leave. The managers then can influence that decision through interventions and these require resources either for quality or RMIs (Athanassopoulos 2000, Keaveney and Parthasarathy 2001). Although probability of retention is not directly linked to resources nor it reflects a financial measure, this is done through its use in customer lifetime value.

The Customer Lifetime Value concept (CLV) has been developed in order to predict the potential monetary value of the customer in the future. CLV is defined as the net present value (discounted profit or loss) of a customer, where profit (or loss) is the revenue that will be generated by the customer after accounting for the cost to acquire and retain the customer as well as the cost of sales discounted by some rate (Berger and Nasr 1998). CLV models[7] focus on the financial expression of resources (budget) that are exchanged between the firm and the customer (Jain and Singh 2002). The firm's resources are money spent on communication for relationship maintenance through phone, face-to-face or direct mail of catalogues (Mohr and Nevin 1990, Shepard 2001, Reinartz and Kumar 2003). Also, there is money spent on maintaining a program that rewards usage like loyalty cards (Lemon and Wangenheim 2009). The marketing executives are then asked to allocate their budget to these activities or RMIs as described in section 2.2. When budget allocation is based on CLV, it includes resources that are reflected in monetary terms (Venkatesan and Kumar 2004). Resources in the CLV context do not include quality explicitly. It can be assumed that quality is reflected in the cost of producing and delivering a service or a product. So, the effect of attributes of quality on customer retention cannot be measured despite their influence.

The direct effect of quality when reflected financially is measured by Return on Quality (ROQ). This metric was introduced to help firms make decisions on quality improvements based on their effect on the firm's finances (Rust et al. 1995). The measure is constructed based on assumptions that quality improvement can be reflected in financial terms and treated as an investment[8]. Any quality improvement is evaluated by the customer, whose perception affects her action (Parasuraman et al. 1985). Customer satisfaction was linked early on to firm profits in a positive way (Buzzell and Gale 1987, Fornell 1992). However, as it is a self-reported subjective measure its accuracy as part of performance is potentially biased (Moers 2005). On the other hand, there is strong support that

[7] For a more detailed review on CLV modelling, the reader is advised to see Jain and Singh (2002) and Gupta and Zeithaml (2006).

[8] Meaning the firm can over-invest and the returns on the investment are diminishing. Please see Rust et al. (1995) for more

the objectivity in the measurement of product and service attributes that drive greatly customer perceptions renders these important especially when combined with the Internet and the availability of information (Wiggins and RaBoy 1996, Blumenthal 2005). This makes attributes that can be objectively measured a key component of marketing decision making (Seggie et al. 2007). This means that ROQ only captures the effect of quality improvement investment at the firm level and is affected by the customers' perception.

Research has shown that the firm-customer relationship is affected by quality dimensions that are non-financial in nature like personal interactions (Grant and Shani 1994). For example, the relationship of the salesperson with the customer is found to affect retention, which makes assigning sales people with varying skills on customers an important resource-related decision although the relevant cost cannot be measured (Crosby et al. 1990). Quality attributes delivered to the customer cannot always be expressed in monetary terms, which makes it difficult to link their effect to the firm's finances and allow managing these at the customer level. The implication in the current research is that it can be to the firm's benefit to include the non-financial quality-related attributes that have been omitted so far and help in allocating these at the customer level.

Marketing decisions on resources allocation that include RMIs and decisions on quality improvement take into account financial data (Rust et al. 1995, Bolton et al. 2004, Bhatnagar et al. 2007). The effect of quality improvement at the firm level on the overall financial performance has been estimated assuming (among others) that any improvement is financially quantifiable (Rust et al. 1995). Quality efforts have been linked to firm's profits through its association to customer satisfaction but not as a finite resource to be allocated. Existing resource allocation models to increase customer retention and handle RMIs are based on customer value, for example Berger and Bechwati (2001) on promotion budget and Venkatesan and Kumar (2004) on customer selection and resources allocation focusing on CLV. Quality as a form of resource allocated to the customers is not treated as such by the existing models. One of the main contributions of this thesis is to address this issue and to develop models that allow for quality attributes to be included alongside traditional retention investment through RMIs.

In conclusion, the literature suggests that customer retention is influenced by RMIs and quality. The resources that refer to these are finite. Taking into consideration their effect on customer retention can help in better allocation. There have been such efforts found in the literature. The investment of resources in RMIs has been modelled at the firm and customer level and the investment in quality improvement has been assessed at the firm level, while quality as attributes that are allocated at the customer level have not been included in any of the known resource allocation models. We find that the firm's retention performance can benefit from such information since quality has been found to have a different effect across customers. We link customer retention to the firm's financial improvement through customers' repeat purchases and cross-buying. So, optimal allocation of quality along with RMIs investment can affect the firm's bottom line. The gap that we identify so far in resources allocation for retention is that quality as attributes delivered has not been considered. The approach pursued must also consider RMIs investment since these influence retention strongly. We remain in the context of marketing performance to pursue further a solution to this problem to be in accordance with demand in marketing accountability.

3 Performance, Benchmarking and Efficiency

Marketing investment on customer retention either through RMIs or through quality improvements is noteworthy (Foster and Gupta 1994, Rust et al. 1995). Marketing decisions are required to not only have a positive effect on the relationships with the customers but also on the firm's finances so that shareholders keep their investment interest (Srinivasan and Hanssens 2009). The shareholder's stake drives the need for accountability and control in marketing activities (Ling-yee 2011). The shift of marketing practice towards the firm-customer relationship has led through research to suggest marketing decisions to be based on customer-focused metrics for better impact on the firm's financial performance (Gupta and Zeithaml 2006). Serving all customers at the same high level is impossible (Zeithaml et al. 2001), so firms are challenged to service and satisfy the most promising ones (Bhatnagar et al. 2007). Allocating resources on customers needs to be done in a way that is accountable and controllable for marketing performance to be assessed (Morgan et al. 2002). In this chapter, we review marketing performance and link to performance measurement so as to propose our approach to allocating resources for the customer retention function.

3.1 Marketing Performance

The pressure from shareholders on marketing accountability and the marketers' need to influence more the firm's strategy have called for the systemization of marketing performance (Farris 2006, Ling-yee 2011, Homburg et al. 2012). Such direction is being encouraged by the Marketing Science Institute's research priorities schedule since 2002 (Lamberti and Noci 2010). Marketing performance incorporates the function's multiple dimensions through a plethora of different metrics (Farris 2006) from using sales as performance metric for marketing (Feder 1965) to proposing Marketing Performance Assessment framework (Morgan et al. 2002). The use of such measurement systems in marketing was assessed by Stathakopoulos (1998). It was also found that the success of marketing performance assessment is more probable when the context in which it is applied is taken into account (Frösén et al. 2013). This means no generic set of metrics is always suitable for all cases, calling for specialization where necessary (Neely et al. 1995, Petersen et al. 2009).

The conceptual Marketing Performance Assessment system (MPA) shown in Figure 1 by Morgan et al. (2002) for example follows a comprehensive approach but also makes sure different firms' operating needs are served. Therefore, management must choose the actual metrics used based on context. The level of the firm's marketing strategy focus on building relationships with customers affects which metrics are chosen (Lamberti and Noci 2010). Although this research does not follow this particular framework, it is used here to illustrate how the firm's resources of various types are actually transformed into customer behaviours that in the end affect the firm's financial performance. Productivity of a transformation process analyses the relationship between inputs and outputs (Fried et al. 2008, Greene 2008). As we narrow down to customer retention tactics, we find that the use of firm's resources that are not necessarily financial lead to the customer behaviours of interest which are repeat purchases and cross-buying. We are interested then to create a metric that assesses this use of resources for better allocation.

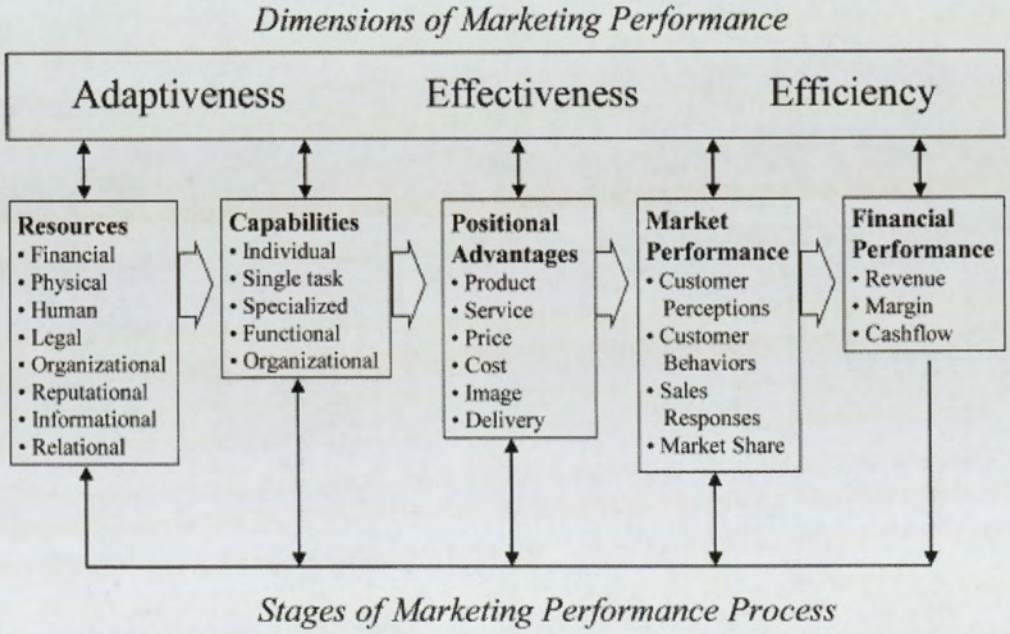

Figure 1 Marketing Performance Assessment System (Morgan et al. 2002)

There are two approaches identified on MPA in marketing literature. The first is marketing productivity and refers to the efficient use of marketing costs and the other is the marketing audit

concept[9] that refers to the effectiveness of the tactics and strategy chosen (Morgan et al. 2002). In the customer retention case that we examine, the RMIs (loyalty reward programs and other long-term activities) and quality have been found effective in retaining customers. So, our focus is on helping the firm to allocate its resources more efficiently. The profit over marketing cost has been a popular marketing productivity metric (Foster and Gupta 1994). This required efforts to appropriately transform the firm's resources, because most inputs and outputs concerning marketing performance were in different units of measurement (Selnes 1992). Reviews on existing systems of marketing performance measurement have recommended including non-financial measures such as service quality (Petersen et al. 2009, Lamberti and Noci 2010, Homburg et al. 2012). The "customers as assets" concept that aims at linking marketing to the firm's performance drives marketing productivity focus on the customer making its measurement more valuable (Sheth and Sisodia 2002, Bolton et al. 2004). It is postulated that the firm allocates its resources on the customers and expects a return (Gupta and Lehmann 2003). We share the viewpoint of the customer being part of the retention function since she is expected to return back the investment of resources, in assessing the firm's retention effort.

Morgan et al. (2002) identify problems in marketing productivity measurement. One issue is the inability to convert all resources in financial measures. Efforts to make such conversions have been found to affect the accuracy of the measurement. Another issue is that there is a black box relationship between the inputs and outputs in the marketing function. When it comes to actually measuring productivity, Sheth and Sisodia (2002) find that absolute measures are meaningless. They argue that any such measures must be benchmarked against another firm or even the firm's past self for retention and acquisition or even better to focus such measures on the customer. Benchmarking helps evaluating and emulating processes of the best performing units and it has been successfully applied in business (Spendolini 1993). There are reports of large and small companies being successful by committing to benchmarking (Camp 1998). In order for benchmarking to be effective,

[9] First defined in Shuchman 1959

improvement goals must be measurable, attainable and actionable (Spendolini 1993). This way, managers don't set ideal goals, but rather use the identified best practices as benchmarks for the rest. Xerox and American Express, for example, have benchmarked themselves against competition to improve their products and customer service (Donthu et al. 2005). In the customer selection for resources allocation, benchmarking the productivity of the customer retention efforts can help in identifying the best cases and use these as guidelines for resources allocation so that goal-setting comes from actually observed behaviours.

The proposed methodology in this thesis to allocate resources for customer retention uses the relative productive efficiency estimate as a measure of performance via benchmarking. Its measure is estimated by Data Envelopment Analysis (DEA), which is a technique based on linear programming that allows analysts to measure the relative efficiency of an entity's production process as benchmarked against the rest of its peers (Thanassoulis et al. 2008). The concepts of performance measurement, benchmarking, efficiency and DEA are not new in the marketing context (Athanassopoulos 1998, Soteriou and Stavrinides 2000, Emrouznejad et al. 2008). One of the important advantages of DEA is that it can include and handle different types of firm's resources simultaneously.

In the next section we will take a closer look into DEA and its applications in Marketing but before we go there, here is a short list of the most important advantages of DEA that will in particular be useful for the models proposed in Chapter 4:

1. Handle multiple types of resources, which is found to be a problem when marketing managers are asked to allocate the firm's resources
2. Identify suitable customers-"assets" for resources allocation by benchmarking, which is found to be necessary for marketing decisions accountability that shareholders need
3. Provide insights and guidelines for the allocation of resources of multiple types based on observed data rather than ideal situations.

3.2 Performance Measurement, Efficiency and DEA

Performance in the business (and marketing) context as explained in the previous section is multidimensional. The broader definition of performance is *the ability of a unit to achieve goals in a setting*, which makes profit or any other indicator more of a reflection of business performance rather than its measure[10] (Fried et al. 2008). This ability, which differs from entity to entity in a given setting, is unobservable and has been used to explain varying differences in producing outcomes. This variation can exist due to differences in production technology, in the scale of operation, operating efficiency, or in the operating environment. Performance in this sense for each entity is focusing on the first three, since these are under their control. To measure performance requires comparing the observed unit against one or more members of the best performing ones. Benchmarking performances against actual observations that operate under the same circumstances produces results that are shown to be feasible rather than artificially set goals[11].

When performance refers to some production process such as the one the marketing department operates (Sheth and Sisodia 2002) the focus lies on the transformation of firm's resources to outcomes produced, namely inputs and outputs (Coelli et al. 2005). The efficiency of this transformation that comes from production economics can explain part of this variation given a constant environment. Efficiency is partly about using resources without waste, in which case it is called technical efficiency and partly about making optimal combinations of these resources given their prices and an objective to be achieved, in which case it is called allocative efficiency. For the purposes of this research, we have shown that the resources come from a finite pool and the goal is to examine possibilities to reduce their waste, whether these resources are financial or not. So, we

[10] Further argumentation on the comparison of profit vs performance as a measure of business success can be found in Fried et al. (2008)

[11] Fried et al. (2008) give the following analogy: "...we do not know, and cannot know, how fast a human can run 100 meters. But we do observe best practice and its improvement through time, and we do observe variation in actual performance among runners."

focus on technical efficiency, since we are interested in identifying room for better resources allocation that are available for customer retention.

Conceptually, units being evaluated, also known as decision making units (DMUs), are using the same types of inputs (resources), the same technology in production process, although with different ability to produce the same types of outputs. These are being compared against each other, in order to identify the best practice DMUs that form the frontier (Thanassoulis 2001). By best practice, it is meant efficiently and more specifically in Koopmans's (1951) definition of technical efficiency: "A producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output" (Fried et al. 2008). The efficient units that form the frontier become the benchmark for the rest, the performance of which can be measured and managed for improvement as well.

The frontier is constructed by the DMUs. The assumption is that all DMUs under assessment use the same production technology and belong to a Production Possibility Set (PPS), which is represented algebraically as follows:

For Inputs $x = (x_1, \ldots, x_N) \in \mathrm{R}_N^+$ that produce Outputs $y = (y_1, \ldots, y_M) \in \mathrm{R}_M^+$ then

$$T = \{(y, x) : x \text{ can produce } y\}$$

So, Koopman's (1951) technical efficiency is stated as:

DMU A $(y, x) \in T$ is technically efficient if and only if $(y', x') \notin T$ for $(y', -x') \geq (\mathrm{y}, -\mathrm{x})$, with strict inequality holding for at least one input or output.

The space that the frontier envelopes along with the frontier itself constitute the **production possibility set**. It is assumed that no DMU can operate beyond the frontier. Debreu (1951) and Farrell (1957) introduced a measure for the technical efficiency. When the focus of the analysis is on reducing the input side of the production then the measure is defined as the radial maximum equiproportionate reduction in all inputs that is feasible with given technology and outputs. When

the goal is to find the maximum feasible output, then this radial measure of efficiency will show the equiproportionate shortfall in all outputs, given the inputs.

We use DEA to estimate the score of the relative efficiency of a DMU. DEA is mathematical programming method that constructs the frontier and assesses each DMU against it to get the measure of efficiency as well as other information regarding the improvement of its performance. It is non-parametric and non-stochastic, which means that no relationship among inputs and outputs need be specified and no noise is assumed for the data. To illustrate the frontier, the efficiency measure and how DEA works as a concept, we will use two examples. The first is a two-input, one-output case to illustrate the frontier in the input space and a two-output, one-input case to illustrate the frontier in the output space.

Assuming there are 4 DMUs A, B, C and D that use two inputs to produce a single output, their combinations of inputs are graphed in Figure 2, normalised per unit of output. It is implicitly assumed here that the DMUs operate under constant returns to scale, which will be discussed later. In this example, the frontier that traditional DEA constructs is piecewise linear, as opposed to a regression based approximation that could make the line smoother.

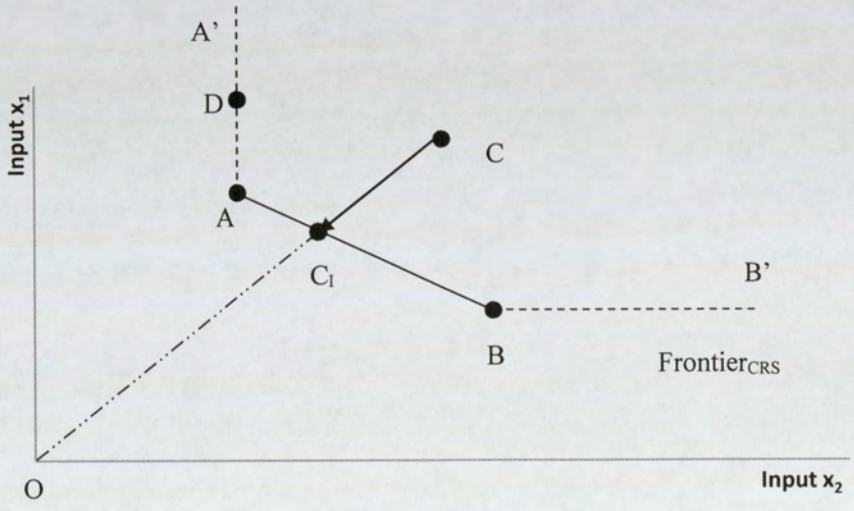

Figure 2 PPS, frontier and technical efficiency representation in the Input space

We can see in Figure 2 that A'DABB' forms the frontier. The radial distance of DMU C from the frontier is the efficiency (or inefficiency) based on the Debreu-Farrell measure, which is the ratio of OC_I'/OC. Based on Koopmans's definition of technical efficiency, only the input combinations that are located on the line AB and not the dashed parts are considered efficient input mixes or Pareto-efficient. The reason is that if a unit or its projection is not part of the Pareto-efficient frontier then it can reduce one of its two inputs while remaining inside the PPS. DMU D is such case, which is efficient based on the Farrell measure since no further proportionate contraction can be made, but can still improve by reducing further Input x_1. This improvement on Input x_1 is called slack and can be quantified in the constraints of the model solved. The radial expansion for the output space can be seen in Figure 3. In this example, there are 4 DMUs E, F, G and H that use one input to produce two outputs under constant returns to scale. The efficient output mix of DMU F is that of F_O', which is the radial expansion of F on the frontier. The frontier is E'EGG', but Pareto-efficient are those units with output mixes that are on the EG line. The efficient output levels of H are those of H'. However, it is found that there is still improvement in Output y_2 captured in the slack variables.

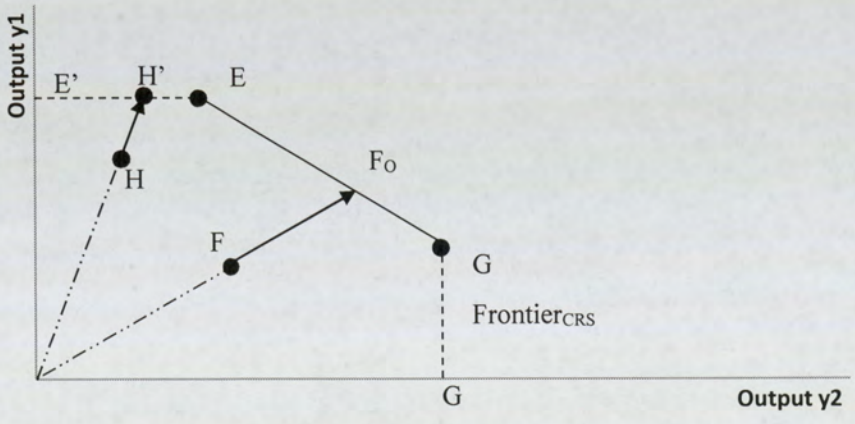

Figure 3 PPS, frontier and technical efficiency representation in the Output space

The next step is to estimate the distance to get the efficiency. The model(s) that are solved to get the efficiency measurement are built based on certain assumptions for the PPS. Thanassoulis et al. (2008) summarize these assumptions. The first necessary assumptions are that all observed DMUs

belong to the PPS and that no output can be produced without some input. Then there are the convexity, monotonicity and returns to scale assumptions that refer to the curvature of the piece-wise linear frontier. Also, there is the minimum extrapolation assumption which means that the PPS is the space that is formed from intersections of the above assumptions. The returns to scale (RTS) assumption refers to the effect of a change in inputs levels on the outputs. In the case where returns to scale are constant (CRS), an increase in inputs for an efficient DMU results in an equiproportional increase in the outputs. Otherwise, the returns are non-constant. The effect that the assumption on RTS has on the frontier and efficiency is shown in Figure 4. In this example, we assume a single-input single-output production.

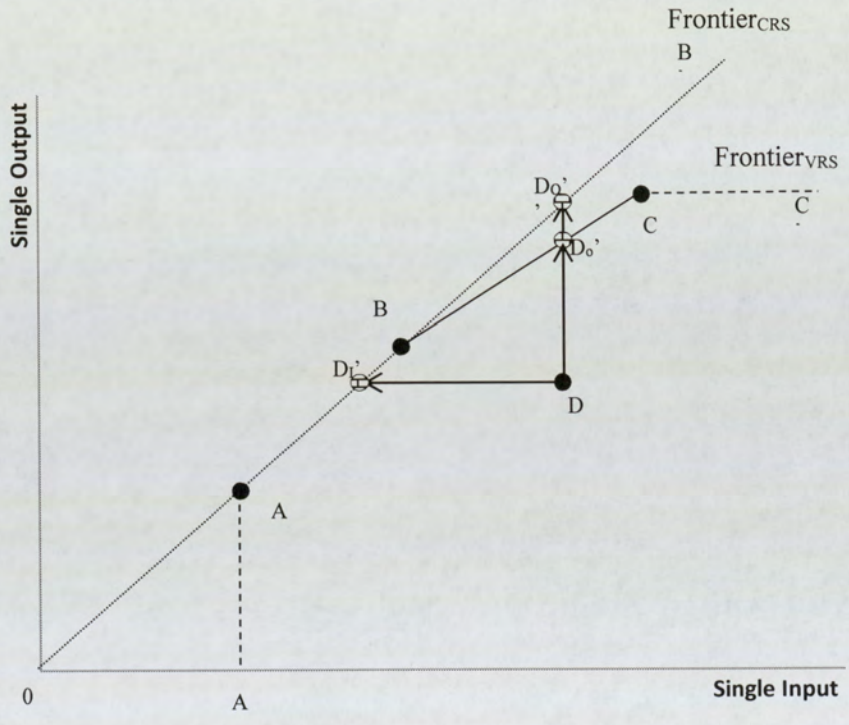

Figure 4 Illustration of CRS and VRS frontiers

Under CRS the frontier is constructed by 0ABB' as DMUs A and B have the highest ratio of outputs to inputs. Under non-CRS the frontier is formed by A'ABCC'. Then DMU D is compared to the respective frontier. This means that if D is in control of its inputs, it should reduce these to those levels of D_I' that are a combination of A and B. Should it increase the output, then the increase should be at levels of D_O' so as to reach pure technical efficiency under non-constant returns to

scale, or D_O'' under CRS. Another useful piece of information is the local returns to scale. DMU C for example can be identified as operating at Decreasing Returns to Scale (DRS), since the proportional increase of inputs in the line BC produces output that is increased in smaller proportion.

The models that are traditionally used to estimate the Debreu-Farrell efficiency measure are solved for each DMU in the set and can be found in Table 1.

DEA models		Short Description
Primary Model (Envelopment Model)	Dual Model (Value-Based Model)	
Input oriented radial efficiency measurement models CRS		DMUs j =1...n Inputs i =1...m Outputs r =1...s DMU_0, x_0, y_0 etc. refer to the DMU under assessment λ is used for the piece-wise linear approximation of the frontier u, v are virtual weights s_r^+ and s_i^- are slack variables w reflects the impact of scale size on productivity
$Min\ \theta_o$ Subject to: $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}$ $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_o x_{io}$ $\lambda_j \geq 0$ Under VRS the following constraint is added $\sum_{j=1}^{n} \lambda_j = 1$	$Max\ h_o = \sum_{r=1}^{s} u_r y_{ro} + w$ Subject to: $-\sum_{i=1}^{m} v_i x_{ij} + \sum_{r=1}^{s} u_r y_{rj} + w \leq 0$ $\sum_{i=1}^{m} v_i x_{io} = 1 \quad u_r, v_i \geq 0,\ w = 0$ Under VRS the following constraint is added w is free instead of $w = 0$	
Output oriented radial efficiency measurement models CRS		
$Max\ \beta_o$ Subject to: $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \beta_o y_{ro}$ $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}$ $\lambda_j \geq 0$ Under VRS the following constraint is added $\sum_{j=1}^{n} \lambda_j = 1$	$Min\ g_o = \sum_{i=1}^{m} v_i x_{io} + w$ Subject to: $\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} + w \geq 0$ $\sum_{r=1}^{s} u_r y_{rj} = 1,\ u_r, v_i \geq 0,$ $w = 0$ Under VRS the following constraint is added w is free instead of $w = 0$	

Table 1 – Linear Programming DEA models

In general, the primary models work by enveloping the DMUs and the tightness of the envelopment depends on the constraints on the lambdas. The value-based models work in the engineering sense of sum of weighted outputs over sum of weighted inputs, but the weights are set by the model. The optimal values of θ, β, h and g are the efficiency estimates[12]. Under CRS the

[12] In order for the efficiency scores to be at the same numerical range, the inverse of β and g are used as efficiency score

efficiency scores are the same for each orientation. In contrast, under the assumption of VRS, input and output oriented models generally yield different measures of efficiency. The models can give through the lambdas, the weights, the slacks and further information about the PPS. This information has to do with the peers or DMUs with dominating performance over the assessed inefficient DMU. By looking at the value of the slacks, it can be checked whether there is further room for improvement for some inputs and outputs, beyond the radial change. A DMU with $\theta_o = 1$ or $\beta_o = 1$ and zero slacks is Pareto-efficient. The projection of the inefficient DMU on the frontier is captured in the models by creating a virtual DMU against which the assessed DMU is compared. As the virtual DMU is created on the efficient frontier, it is rendered a target for the DMU under assessment. This virtual DMU has input and output levels that are targets that can be suggested for reach. This makes DEA valuable as a benchmarking tool. The issue of the targets is discussed in later chapter.

In the context of the current study, DEA can help in handling multiple resources that are not necessarily expressed in the same measurement unit and help in the issue of handling financial and non-financial resources. The analysis can be done at the customer level that is the needed focus of any assessment of marketing activity. Its benchmarking function can provide guidelines for better allocation of the resources used. The relativity of measurement will solve the issue of setting standards that are infeasible. Finally, Some of DEA's main uses are summarized by Thanassoulis et al. (2008):

- Estimation of the relative efficiency of a DMU
- Identification of "suitable" efficient peers for an inefficient DMU to emulate
- Estimates of input-output levels that would render a DMU efficient
- Measurement and decomposition of the change in the productivity of a DMU over time
- Identification of the type of returns to scale holding locally at some efficient DMU

- Identification of the most productive scale size (MPSS) for a DMU

The efficiency scores, the input-output levels of efficient operation, the local returns to scale as well as the MPSS are concepts that are going to be used further in this research. These will be estimated numerically in the context of retention performance to support allocation of relevant resources. Benchmarking using DEA has been used in the marketing function of the business before.

3.3 DEA applications in marketing

Emrouznejad et al. (2008) report more than 4000 pieces of published work for the first 30 years of DEA across different industries. DEA applications can be found in many industries like banking (Portela and Thanassoulis 2007), education (Thanassoulis and Dunstan 1994), retail (Athanassopoulos and Thanassoulis 1995) and regulated utilities (Thanassoulis 2000) among others. When it comes to marketing, Charnes et al. (1985) supported the use of DEA in marketing management based on its ability to show managers what can be actually changed when the priority is to accomplish a goal. Applications to that end showed potential for supporting marketing decisions (Athanassopoulos and Thanassoulis 1995, Seiford and Zhu 1999). Since marketing productivity is important to marketing accountability (Sheth and Sisodia 2002), DEA was further supported as a helpful concept in that direction (Luo 2004).

DEA applications in marketing assess the relative performance of functions like for example advertising (Luo and Donthu 2001), market efficiency for customer attraction (Athanassopoulos and Thanassoulis 1995, Athanassopoulos 1998) and sales (Mahajan 1991), while the industries include banking (Soteriou and Stavrinides 2000), retail (Donthu and Yoo 1998) and hospitality (Keh et al. 2006). The list is not exhaustive. To improve marketing performance it needs to be measured beyond its effect on bottom line because of its multidimensional nature (Sheth and Sisodia 2002). The fact that DEA handles multiple input and multiple output processes and benchmarks units has been useful in marketing applications, because of the multiple goals the marketing function is set to achieve. The multiple resources that banks utilize and the many products that they produce can be handled by DEA to get the efficiency of attracting sales even when non-financial resources are being

considered (Athanassopoulos 1998). In another application, the managers can improve their unit's retail productivity more from having the *best* to look up to rather than comparing only to themselves (Donthu and Yoo 1998). The assessment of performance of advertising campaigns using DEA can help firms in the same industry to improve it by focusing on quality factors like medium (TV, outdoors etc.) and content (Luo and Donthu 2001). So, DEA can contribute in measuring marketing productivity by identifying best performers and setting benchmarking goals.

There is something in common in the above applications. The assessment is done at the firm or branch or outlet level either focusing on the whole operation or just the marketing function. This means that the process that is benchmarked is that of a business unit. As the focus of marketing decisions is on the customers, so should the metrics developed and used for this purpose. In DEA applications we find the customer to be the decision making unit in the concept of customer efficiency as part of the service co-production process (Xue and Harker 2002). However, the exchange of resources for maintaining the relationship requires both parties to participate. This research aims at looking neither at the firm nor at the customer alone and the efficiency of their corresponding efforts but as a pair that exchange resources in order for their relationship to grow. We focus on the retention part of the relationship or *maintenance* as opposed to acquisition or *formation* according to the relationship marketing terminology in Chapter 2. Retention is a part of the marketing operation and its performance is proven to be strongly linked to the firm's bottom line. Based on the efficiency of this operation we propose the allocation of the firm's resources on this function.

4 Firm – Customer Relationship Efficiency

Customer retention has been found to be influenced by the firm through its relationship marketing instruments and quality as shown in sections 2.2 and 2.3. The important effect of customer retention on firm's bottom line has led marketing performance research to the development of relevant metrics, the most popular at the customer level being CLV. Decisions on resources allocation based on CLV have been modelled, but these do not consider quality neither explicitly in estimating CLV nor as a resource to be allocated. So, a new concept is introduced, defined and operationalized here to try to cover this gap. This new concept is developed on a marketing performance basis that looks at how productively the firm's marketing resources are used for customer retention. To that end, we model the efficiency with which the retention function operates in the firm so as to make suggestions on the allocation of RMIs investment (monetary) and quality (non-monetary) components at the customer level. The term of Firm-Customer Relationship Efficiency (FCRE) is developed in this chapter and defined as follows:

Firm Customer Relationship Efficiency is the relative measure of the performance of the firm's retention function. The efficiency refers to the process of allocating resources on each relationship for the purpose of increasing retention that are transformed into customer's repurchases and cross-buying.

This efficiency refers to the relationship rather than the firm or the customer solely. For simplicity we refer to FCRE as the efficiency of the customer interchangeably. The level of that efficiency can help the firm avoid wasting and overspending resources. Its measurement can make these decisions accountable and hence manageable. The firm's retention performance, given the fact that it needs to account for monetary and non-monetary components, is being pursued from a productivity perspective as explained in sections 3.1 and 3.2. We look at the retention function as an input-output process and through the productivity perspective we can measure how efficiently this function operates. This measurement is done using benchmarking. We use the firm-customer relationship as the unit of assessment and we measure the ability with which the firm's investments are transformed

into customer's retention behaviour relative to other customers. For its measurement we adopt DEA as an instrument as it can handle multiple inputs and multiple outputs measured in different units. The use of DEA also offers additional insights that allow for the firm to improve the performance of its marketing retention operations. In order to fully comprehend FCRE it is necessary to go through the next steps that will support the concept and the methodology to define and finally measure FCRE. These steps are the conceptualization of the Firm-Customer Relationship as an Input-Output Process, the conceptualization of FCRE and the DEA models that will be used to numerically assess FCRE and the suggestions on using relevant insights from modelling for improving performance.

4.1 Firm-Customer Relationship as an Input-Output process

In chapter 2, the retention of the relationship between the firm and the customer and how the firm influences it were discussed. The retention of the relationship requires an ongoing effort from the firm to influence the customer's behaviour to remain engaged in the relationship apart from providing service to satisfy the customer's needs. This effort consists of investment in relationship marketing instruments (RMIs) and these include loyalty reward programs and direct marketing efforts that have long-term effects. Another part of the firm's effort to influence the retention of the firm-customer relationship is the quality delivered to the customers. As seen in sections 2.2 and 2.3, quality of service or product and relationship marketing efforts have an effect on satisfaction and loyalty that lead to repetition of purchases and cross-buying. **The main feature of interest in this process is that the firm invests resources and the customer responds using her resources (by purchasing).**

We see this process as a transformation of inputs into outputs. The inputs in the relationship come from the firm in the form of investments that aim at retention. The firm can see repurchases of primary goods and cross-buying as the outputs created by the customer. Table 2 shows the key elements that are included in the exchange process between the firm and the customer. The main focus lies on elements of marketing activities' costs, quality of service/product delivered, revenue

and cross-buying activities. Therefore, the following table includes these elements in a way that supports the concept of the retention function as an input-output process.

Firm resources allocated to the retention of the relationship	Customer's resources as responses to retention
• RMIs Investment • Quality Delivered	• Revenue from Core Product Repurchases • Revenue from Cross-Buying

Table 2 - The Firm-Customer Relationship as an Input – Output Process

Relationship Marketing Instrument Investment: This component includes all the relationship marketing activities' cost that has been invested on each customer. It is assumed that the higher the cost, the bigger the effort to retain that customer.

Quality Delivered: As opposed to perceived service quality, we use quality delivered to capture the firm's effort to provide quality to the customer. This can be a single metric that the firm uses to measure quality in products/service or can be an aggregator of measures. The unit of measurement has no effect on the interpretation of the results. Quality delivered captures the firm's non-monetary resource allocated in its relationship with the customer. Discussion on why we don't use a measure of customer's perceived quality is in section 2.3

Value of Repurchases: It refers to the value of the core product or service repurchases. Defining the core product is not always easy. For example, in a retail environment, the core products are the products found on the shelves, excluding other side services like home delivery, retailer's insurance and so on. Nevertheless, this must be decided during the design phase of the project in cooperation with the management team.

Value of Cross-Buying: Refers to the revenue generated by purchasing products that are not associated to the firm's core products. For example, a car dealership that sells car insurance or leather seats for a car. Again, defining cross-buying needs stakeholders' contribution.

Proposition:

Retention as a marketing function is a process through which the firm allocates its resources on the customer to influence her decision to remain in the relationship and the customer responds by allocating her resources in the form of repurchases and cross-buying.

The firm-customer relationship is maintained by an exchange of resources. So far, the retention function has been discussed from the firm's standpoint. The exchange of resources means that the customers also take part and their purchases can trigger the firm's response. This interactivity is captured in the current concept. The inputs and outputs can be reversed to give the customer's perspective in the relationship. The customer also provides inputs by making purchases and the firm looks to retain and grow such behavior through relationship marketing investments and quality delivery. Both perspectives are taken into account in assessing the firm's retention performance.

4.2 Firm-Customer Relationship Efficiency Concept

Perceiving the retention function as an input-output process allows for the productivity concept to be used. The efficiency with which the inputs are transformed into outputs can show how the retention function performs to that respect and help the firm adapt accordingly. The performance of the retention function of the firm is assessed at the customer level by benchmarking against best observed customer behavior in this context. The "best" observed behavior or relationship is that which is allocated the least retention resources for the value of the repurchases and cross-buying by the customer. Customers displaying best relationships as defined here form a frontier that sets standards for the rest of the customers. The efficiency of the retention of each customer or 'DMU' reflects how close the customer's behavior is to that of those on the frontier. So, the firm has information on how productive the retention function is at the customer level.

The measurement of the efficiency using DEA provides helpful insights on the retention function apart from the efficiency itself. The firm can measure waste of resources that are due to the retention not being efficient. The relative efficiency shows the reduction in the levels of the firm's resources that can be possible. The levels of the best observed customers in this context are the possible ones. The effort in delivering quality is also estimated as it can be resource-intensive. Using DEA to

measure FCRE we can estimate waste for both RMIs and quality simultaneously. This is different to existing metrics, as the return on RMIs investment and quality was estimated separately and only if quality was reflected in monetary terms.

There is evidence that contacting customers for retention too much has a negative effect on purchases (Fournier et al. 1998, Venkatesan and Kumar 2004). So, apart from the waste, we are also interested in examining this negative impact on customer retention. This means that we expect RMIs to reduce the value of repurchases and cross-buying after a certain level. On the other hand, quality improvement although showing diminishing positive effect on retention has not been found to reach at such level that can cause negative impact (Steiner et al. 2014). In terms of efficiency, this negative impact on the output after a certain level of input is called congestion and we measure this effect with complementary modelling that will build on that of measuring waste.

Estimating the waste and congestion levels of the resources allocated to retention can help the firm plan its marketing strategy at a firm level. The benchmarking of the relationships allows the firm to have insights on the allocation of resources at the customer level apart from the aggregate level. The efficiency of the relationships is estimated based on observed combinations of inputs and outputs rather than ideal or artificially set standards. These observed mixes of inputs and outputs or their linear combinations may serve as targets for the inefficient ones. The technique we are adopting assumes that a DMU (customer) can move freely inside the production space and suggested to move towards its target. This may cause an issue if some relationships are suggested to incur changes in the retention effort that can be deemed risky by the firm. We propose that the reduction of waste and congestion be done gradually and in as small moves as possible while at the same time following the minimum distance to the better performing relationships. For this reason we will use the layering technique as in Thanassoulis (1999) and Paradi et al. (2004). Each time the efficient relationships are removed from the comparison set and new ones are identified as best practices forming layers of frontiers. This way each relationship will be compared against and targeted to peers or their convex combinations that will be as close as possible based on observed inputs and outputs. The

firm then will be provided with suggested improvements in its use of resources that are smaller than the initial analysis.

4.3 FCRE Models

So far it has been explained how the firm's function of retaining the relationship between the firm and the customer can be seen as an input-output process and how looking at its efficiency can provide the firm with insights on its resource allocation performance for that purpose. The next step taken here is to present the models that will be used to numerically assess FCRE. It will also be shown how additional information, such as waste of resources, congestion due to excessive investing, effect of the scale of retention investment on the retention performance and resource allocation targets is provided through the models.

Principles of DEA are explained in section 3.2. In summary the reason behind choosing DEA is the following:

- DEA is a non-parametric method. It does not need to specify the functional form of the relationship of the inputs and outputs. In this case, we do not need to assume how quality and RMIs affect the repurchases and cross-buying.

- It is also unaffected by the units of measurement of the inputs and outputs. In this case, we do not need to convert quality into money like the other three elements of the model.

There are two components of the DEA modelling that we need to address. The first one relates to the set of inputs and outputs and the second one relates to the assumptions of the model. The set of inputs and outputs has been discussed in section 4.1. So far as assumptions are concerned, the first one relates to the orientation of the model. The orientation affects the end-use of the information produced. An input orientation means that the end-user is interested in the minimization of the inputs, whereas an output orientation means that the end-user's goal is to maximize outputs. The orientation of the models in this research is towards minimizing the inputs, the waste of which the firm wants to control. The second assumption refers to the returns to scale as shown in Figure 4 on

page 37. The model is constructed based on the non-constant returns to scale assumption known as VRS. This means that an increase is allowed to produce repurchases and cross-buying of variable proportionally depending on the current location on the frontier. A natural consequence of VRS is that it allows a customer with low levels of investment and purchases to be more likely to be compared against another customer with similar levels of investments and purchases. This allows for more feasible reductions of levels of waste to be suggested. The models solved to estimate the efficiency score are in Table 3.

<table>
<tr><td colspan="2">DEA models</td><td rowspan="3">Short Description</td></tr>
<tr><td colspan="2">Input oriented radial efficiency measurement models under non-CRS</td></tr>
<tr><td>Primary Model
(Envelopment Model) (1)</td><td>Dual Model
(Value-Based Model)</td></tr>
<tr><td>First Stage

$Min\ \theta_o$
Subject to:
$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{ro}$
$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = \theta_o x_{io}$
$\lambda_j \geq 0$
$\sum_{j=1}^{n}\lambda_j = 1$</td><td rowspan="2">$Max\ h_o = \sum_{r=1}^{s} u_r y_{ro} + w$
Subject to:
$-\sum_{i=1}^{m} v_i x_{ij} + \sum_{r=1}^{s} u_r y_{rj} + w \leq 0$
$\sum_{i=1}^{m} v_i x_{io} = 1 \quad u_r, v_i \geq 0,$
w is free</td><td rowspan="2">DMUs j =1...n

Inputs i =1...m

Outputs r =1...s

DMU_0, x_0, y_0 refer to the DMU under assessment

λ is used for the piece-wise linear approximation of the frontier

u, v are virtual weights

s_r^+ and s_i^- are slack variables

w reflects the impact of scale size on productivity</td></tr>
<tr><td>Second Stage

$Max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$
Subject to:
$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{ro}$
$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = \theta_o^* x_{io}$
$\lambda_j \geq 0$
$\sum_{j=1}^{n}\lambda_j = 1$
θ_o^* is optimum solution from First Stage</td></tr>
</table>

Table 3 DEA Model to estimate waste of retention resources

We estimate the efficiency scores by solving these models for each customer. Any inefficiency identified is causing waste that reduces the retention performance. Further improvement can be captured in the slack variables. The slacks in the primary model constraints capture additional improvements in either one or more of the inputs and outputs. The problem that these solve has to do with aligning the Farrell measure of efficiency with Koopmans's definition of technical efficiency as discussed in section 3.2. In managerial terms, organizational slack is defined as institutional resources that are under-utilized and act as buffer for uncertain situations (Cyert and March 1963). From the organizational theory perspective it is part of the strategy employed and is evaluated as such (Adkins 2005). Should the firm intentionally allow for organizational slack, then these resources can be assumed necessary to exist and not considered waste (Banker et al. 1989). In the case of retention performance, slacks in the inputs can be used as buffer for keeping customers satisfied, while slacks in the outputs can be used as sales targets. The rest of the DMUs that are found inefficient can be allowed for organizational slack by being compared against a selected peer that is not part of the frontier (Post and Spronk 1999). The layering technique we discuss in section 4.2 allows different peers to act as comparators apart from the ones on the frontier. We discuss later in this section how this technique works.

Apart from the firm's perspective on retention, we also model the customer's perspective of this retention process. We follow the concept of two opposite frontiers in the same production set. The two frontiers can indicate alternative performance goals as in Athanassopoulos and Karkazis (1997). Another concept of the two frontiers is in identifying not only the best practices but also the worst (Paradi et al. 2004). The retention efficiency from the customer's perspective is equivalent to the worst practice frontier and the firm's perspective frontier identifies best practices as we still focus on the firm's goal to minimize waste. Should the customers be aware of the resources allocated for retention, they would look to maximize the resources the firm allocates to them and minimize theirs. As this is not the case, this frontier can be useful to the firm to identify worst performers. In the case of the retention function we consider the firm's investments as outputs and the customer's purchases

as inputs instead of inputs and outputs respectively as used in the waste model. We solve model (1) to estimate the customer's perspective efficiency score.

In order to implement the layering technique, the models are solved and each time the efficient DMUs are removed from the set and the models run again. There are multiple frontiers estimated as shown in Figure 5. Assuming there are 7 DMUs to be assessed with a single input producing a single output under non-constant returns to scale, the first solution of the model (1) for DMU H finds it inefficient with the input oriented score θ_1 being equal to $0H_i'^*/0H_i$. The frontier is A'ABCC'. Removing efficient DMUs A, B and C and solving model (1) again for DMU H, will give an input oriented efficiency score θ_2 equal to $0H_i^{*''}/0H_i$. As $\theta_1 < \theta_2$, the target for H is now closer to its current input-output mix. This way, we make sure that DMU H is not suggested to change its mix based on some DMUs that can be found with atypical performances. In the case of customer retention, we make sure management is not suggested to make allocation decisions upon strict evaluations.

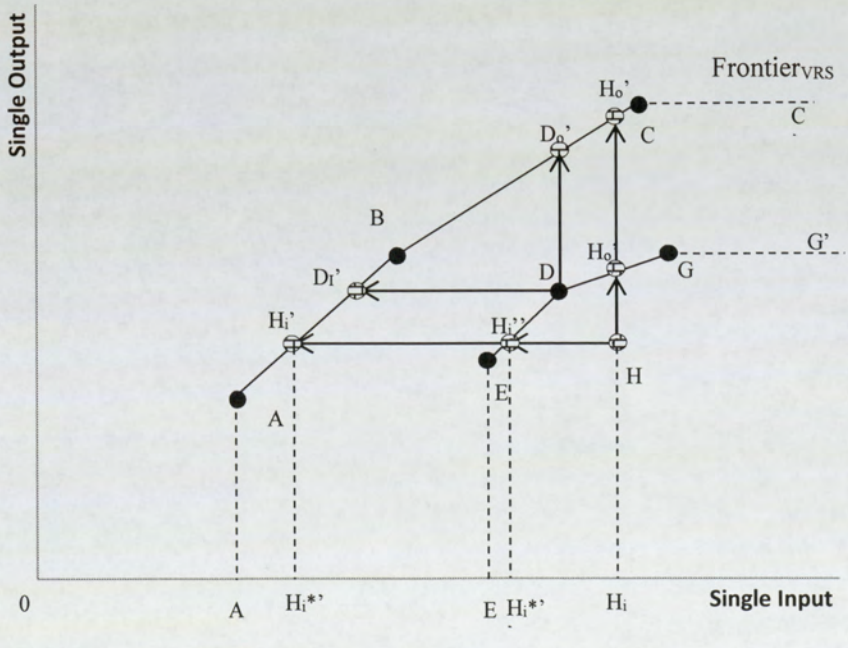

Figure 5 Frontier estimation using layers

In the production processes examined so far, including the examples or the retention function of the firm, it is assumed that for an efficient unit any unwanted quantities of inputs can be disposed of without any cost to the outputs, meaning that the production unit still maintains its efficiency. This is the assumption of strong disposability (Thanassoulis et al. 2008). However, there is the case where excess inputs can block the production of output quantities and eliminating these requires resources. In production terms this means that a proportional increase in the inputs will produce smaller quantity of outputs still operating efficiently, making the inputs weakly disposable (Färe et al. 1989, Färe and Grosskopf 2000). This production characteristic is affecting the frontier and hence a unit's efficiency and is assumed to be causing congestion. It has been researched using DEA in cases like China's labour increase actually reducing production of outputs and not just because of managerial inefficiency (Brockett et al. 1998) or British universities' research and degrees output being congested by rapid increase in students intake (Flegg and Allen 2007) among others. We use the example in Thanassoulis et al. (2008) to show the effect of congestion. The dashed line segment DD' in Figure 6 is the frontier extension should strong disposability of inputs was assumed. Weak disposability means that the observed mix that is DMU E is part of the frontier. For this particular single-input, single-output example, the effect of the input congestion in the quantity of the output of DMU E is its distance from DD' as the output level of DMU D is the maximum observed. The congesting input quantity is EE_c and that of inefficiency is E_cB.

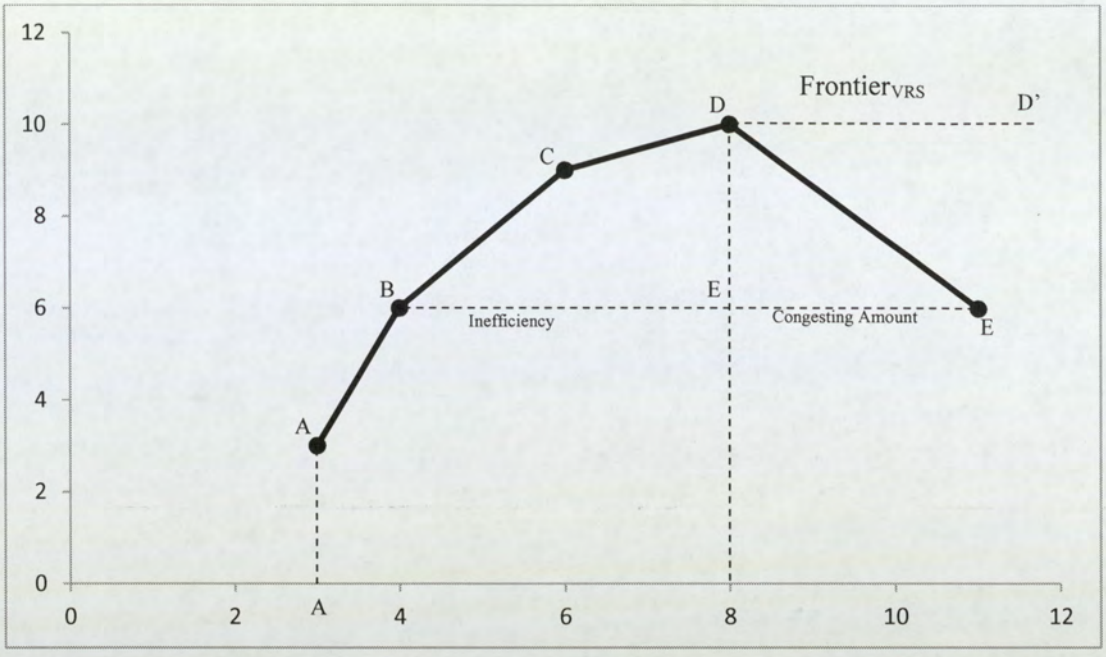

Figure 6 Weak disposability of input (Thanassoulis et al. 2008)

In the retention function, we expect excessive investment in RMIs to reduce repurchases and cross-buying as explained in section 4.2. The first method published by Färe et al. (1985) measured the degree of congestion as the ratio of the efficiencies estimated based on the assumption of strong disposability over that on weak disposability of inputs. Cooper et al. (2001) identify issues on this method. The first has to do with ignoring outputs being reduced when inputs are increased as a signal of congestion. The second issue is that when inputs change proportionally, then any inefficiency is attributed to scale inefficiency, rather than congestion. To estimate this effect we use the approach of Cooper et al. (1996), also known as CTT model, which is not affected by these issues. This approach is based on identifying congestion taking into consideration the inputs excesses and the outputs shortfalls and is not affected by any scale inefficiencies (Cooper et al. 2001, Brockett et al. 2004). Inefficiency is measured based on an output-oriented VRS model and then input slacks are maximized. So, congestion is the difference between the input slacks of the two stages. The models to be solved are in Table 4. We make an addition to the CTT model in order to allow for only one of the two inputs to cause congestion. The RMI investment is expected to reduce repurchases and cross-buying when in excess, while the quality delivered is not. To accommodate this, we add the intensity constraint for that input assuming that any slack observed in quality is due to pure technical

inefficiency. Congestion is a boundary-concept (Brockett et al. 2004), so any amount of congestion of RMIs investment is estimated based on the frontier of all the assessed relationships. This means that layers are not going to be used for its estimation.

<table>
<tr><td colspan="2">DEA Congestion models</td><td rowspan="2">Short Description</td></tr>
<tr><td colspan="2">Cooper et al. (1996)</td></tr>
<tr><td>First Stage (2)*

$Max\ \varphi_o$
Subject to:
$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \varphi_o y_{ro}$
$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}$
$\lambda_j, s_i^-, s_r^+ \geq 0$
$\sum_{j=1}^{n} \lambda_j = 1$</td><td>Second Stage

$Max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$
Subject to:
$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \varphi_o^* y_{ro}$
$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}$
$\lambda_j, s_i^-, s_r^+ \geq 0$
$\sum_{j=1}^{n} \lambda_j = 1$
φ_o^* is optimum solution from First Stage</td><td rowspan="2">DMUs j =1...n

Inputs i =1...m

Outputs r =1...s

DMU_0, x_0, y_0 refer to the DMU under assessment

λ is used for the piece-wise linear approximation of the frontier

u, v are virtual weights

s_r^+ and s_i^- are slack variables</td></tr>
<tr><td colspan="2">Estimation of input slacks due to pure technical inefficiency (3)
$Max \sum_{i=1}^{m} \delta_i^-$
Subject to:
$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^{+*} = \varphi_o^* y_{ro}$
$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^{-*} - \delta_i^- = x_{io}$
$\lambda_j, \delta_i^- \geq 0$
$\sum_{j=1}^{n} \lambda_j = 1$</td></tr>
</table>

Estimation of input slacks due to pure technical inefficiency only for inputs $\bar{I}$ that are assumed to be able to congest the outputs **(4)** $Max \sum_{i=1}^{m} \delta_i^-$ Subject to: $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^{+*} = \varphi_o^* y_{ro}$ $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^{-*} - \delta_i^- = x_{io}$ $\sum_{j=1}^{n} \lambda_j x_{\bar{i}j} + s_{\bar{i}}^{-*} = x_{\bar{i}o}$ $\lambda_j, \delta_i^- \geq 0$ $\sum_{j=1}^{n} \lambda_j = 1$	
Congestion in input I $s_i^{-c} = s_i^{-*} - \delta_i^{-*}$	
*Numbering of Models continues from Table 3	

Table 4 CTT approach to measure congestion Cooper et al. (1996)

5 FCRE Application

FCRE is measuring the efficiency of the retention function at the customer level. The data needed to implement the models must include key information such as transaction information, communication and promotion data, service usage and most importantly quality related information. These can be found in businesses that apply customer centric principles and keep records of the customers' interactions with the company. Companies that operate online are more likely to hold such data. We apply the FCRE model developed in this thesis on an online DVD rental company. We aim at four goals in this chapter. First, we estimate the frontier and identify efficient and inefficient firm-customer relationships. Second, we show at the firm level the RMIs overinvestment and its negative effect, the waste of resources and the potential increase in sales. Third, we suggest how the firm can improve its retention performance based on the analysis. The chapter begins with a description of the data used for the implementation of the models then modelling issues and finally results and our recommendations.

5.1 Case Study

The models developed have been applied to the case of an online DVD rental company based in London. At the time of market maturity, the company was among the top 5 players in the UK. Currently, it is the only one remaining next to Amazon. The operation of the company follows the business model of the industry. The customer creates an account where a subscription level is selected. Each level indicates how many discs a customer can have at the same time in her possession and an upper limit for the discs that can be mailed in total in each billing cycle. In this case, the available subscription levels range from 1 to 8, where 8 is the most expensive and allows the customer to receive the biggest number of DVDs compared to the other 7 subscription levels. The customer creates a ranked wish list of the movies desired to be mailed to her that are in stock and that list is updated at the customer's will. The firm allocates discs to each subscriber and posts these. The company makes an effort to keep as many customers as possible satisfied by having in stock those movies that are the closest to the top positions of the customers' lists. The firm also makes

offers to the existing customers to keep them retained like rewarding their loyalty and word-of-mouth communication. Membership is renewed at the end of the billing cycle automatically unless the customer cancels. The company also offers DVDs for purchase, gift subscriptions and extra rentals.

Customers are retained in general by being mailed the movies they want the most and being influenced by the firm using loyalty and recommendation reward schemes. The firm does its best to allocate the customers the movies they want by optimizing the allocation process and by making the necessary inventory purchases. This requires from the firm to make efforts on the quality of the service that is delivered to its customers. The firm also invests resources in its relationship marketing instruments. Since these are finite, the firm needs to allocate these in an efficient manner, meaning to invest the least possible for their return on investment, meaning repurchases and cross-buying. FCRE measures this efficiency. The decision on how to allocate these resources can be supported by identifying the minimum quantity of firm's resources for a given amount of purchases. So, FCRE is to be estimated for each firm-customer relationship, namely DMU. Based on the differences in observed efficiency we make suggestions to support the retention function.

Each customer is satisfied partly by being sent DVDs from her personal wish-list at the highest ranking possible. Given that a budget is used to update the inventory and manage in this way this dimension of quality, keeping all customers equally satisfied all the time would be impossible. Even if it was, then each unit of quality delivered would not incur the same cost even when allocated to the same customer. Therefore, the firm can handle quality delivered at the customer level and then manage the inventory separately. Quality as a concept also includes other dimensions like customer service. The decision on the rank of discs mailed is made at the customer level, while decisions on the rest of quality dimensions affect the whole customer base equally. We choose to focus on this dimension that is variable at the customer level. So for retention purposes, the firm needs to associate the two different inputs (Quality and RMIs) to the financial goal that management is seeking. The efficiency measurement we propose can support management in this task and we demonstrate in this chapter how it can be operationalized.

5.1.1 Firm-Customer Relationships Sample

We apply the concept of FCRE taking into consideration the firm's business context. The firm operates a subscription-based business model. The customer pays in the beginning of the membership period e.g. first day of the 30-day membership. This allows the firm to know which registered customers are active and which are not. We assess retention performance on the active customers, since allocation decisions are made on them. The data that were provided cover the 24-month period between March 2007 and February 2009. Information in the data covers account creation, account termination where applicable, relationship marketing efforts, movies rented, membership and other offered products purchases. The goal of the analysis is to apply FCRE models to the customers that are active, so customers that have not churned by the end of February 2009 are eligible. Further filtering is applied.

For the retention function to be assessed, we needed to select those customers that had actually made a repurchase, meaning they had renewed at least once their membership and they had paid for it. As some customers' first membership cycle was part of a promotion, it was free of charge. Therefore, a second and a third renewal paid were minimum requirements for those customers to be included in the analysis. In conclusion, we have selected such a sample that can give FCRE scores of lifetimes of relationships in the company that can be actually affected by the firm's retention efforts.

Sampling rules	For customers to be included in the sample the account must: • Be created after March 1st 2007 • Be active • Have value of Repurchases > 0 • Have at least 1 DVD without any problems received and mailed back

Table 5 – Sampling rules

After applying these filters in the available dataset, we end up with 1208 customers and their lifetime history. Next, we explain how we define and estimate the inputs and outputs of the conceptual model in this case study.

5.1.2 Inputs and Outputs from Data

In order to implement the model, the relationship marketing efforts, quality delivered, repurchases and cross-buying were extracted from the data and aggregated accordingly. All relationship marketing efforts that were part of the firm's influence on retention were summed up, as well as the purchases that were expressions of cross-buying behaviour.

Firm's Investments:

1. Relationship Marketing Instruments

This type of investment on behalf of the firm aims to retain existing customers. The estimation of the investment includes the opportunity cost for all the retention schemes run by the firm that were rewarding customers for continuing their relationship with it through engagement and word-of-mouth communication. Such schemes include the "recommend-a-friend" scheme as well as rewards for being a useful[13] movie reviewer. The rewards come in price discounts or DVD purchase vouchers or even free rental time extension. Note that these rewards could not be cashed out therefore the retention investment variable includes the value of this investment. For example, a customer who receives a £20 voucher for purchasing a DVD and a £15 discount for purchasing a gift subscription is attributed a retention investment of £35.

2. Quality Delivered

According to the management team, the higher the disc sent in the customer's wish list, the better the quality of the service. This quality delivered attribute is under the control of the firm in the short-run by controlling the allocation process of the discs and in the long-run by making movie purchases for their inventory. As we aim to help the firm improve its decision making process for the resources it requires to deliver desired quality, we use as quality index the number of discs sent that are in the Top 3 of the customers' wish list.

[13] As voted by the other members of the service

Customers' responses as Retention:

1. Core Service Repurchases Value

This is the sum of the monetary value of the customer's repurchases of membership subscriptions in her lifetime in the sample without discounts as these are incorporated in the relationship marketing instruments. The value is actually the sum of the prices of the membership level at each purchase or renewal time regardless of any discount. It is the price any customer should pay for that particular membership at that time. The repurchase of the membership service is the response of the customer to the investment of the firm. Repurchases are membership renewals that follow the first paid purchase as defined in 5.1.1.

2. Cross-Buying Value

The products available to customers apart from the rental service are movies purchases and gift subscriptions. As the core service is the DVD rental, the DVDs for sale and the gift subscriptions are complementary that are offered for cross-buying. The variable used is the sum of the monetary value of the purchased DVDs and/or gift subscriptions without any discounts.

The table below shows the firm's investments and the customer's resources that are going to be used in the FCRE models.

Firm's Retention Influence	**Customer's Retention Behaviour**
• RMIs Investment (Total Cost for retention campaigns • Quality Factor (Average ranking position of Discs sent in Customer's wish list)	• Core Service Value (DVD Rental Membership value without discounts) • Cross-Buying Value (Total Value of DVD purchases, gift subscriptions etc.)

Table 6 Firm's Investments and Customer's Responses - The Online DVD Rental Case Study

The 1208 firm-customer relationships that have been sampled based on the rules of Table 5 and the corresponding customer lifetime history are gathered to be analysed. The history of the customers includes apart from the inputs and the outputs information on payments, discs mailed,

acquisition method and account status information. Before proceeding to assessing the retention performance we investigate the dataset.

The average lifetime is 280 days with an average profit of £42.60. Around 80% of these have been acquired through some promotion campaign that offers an amount of time free of charge to allow for trial of the service. The customer of the sample's relationships receives an average of 36 DVDs. The average RMI investment based on the relationships in the sample that were allocated some is £11. The fact that many customers were not allocated resources for RMIs is discussed in the next section. In terms of quality delivered on behalf of the firm, the average number of discs sent to a customer from the Top 3 positions in her wish list was 21. These investments by the firm had the effects of repurchases and cross-buying. On average the value of the repurchases was £69 and the average cross-buying value across the customers who made such purchase is £11, while across the sample the average is £0.87. A summary of descriptive statistics can be found in Table 20 and Table 21 in the Appendix. The data bring up an issue that needs to be addressed and that is the existence of zero values in RMI investment and Cross-Buying Value. In the next section, we explain how we deal with this.

5.2 Treating Zero Values in the FCRE Model

Looking further into the dataset, we find zero values in RMIs investment and Cross-Buying value for some firm-customer relationships. The relationships in the sample with zero and non-zero values are summarized in Table 7. When zero values are found in the output side which is the case for Cross-Buying Value, there is no effect in the models that are used for FCRE as in section 4.3. Technically, the output constraint is feasible for zero values in the output for any peer set in CRS and VRS technologies (Thanassoulis et al. 2008). When it comes to RMIs Investment this is a potential problem as DMUs with zero inputs may be found efficient in a DEA model artificially because they can only be compared with a limited subset of relationships, namely those that have zeroes in the same inputs. This means that the model is forced to set as a peer at least one DMU with zero input regardless of the levels of the rest of its inputs and outputs (Thanassoulis et al. 2008)

	Observations with Zero Values (as % of all relationships in sample)
RMIs investment	99%
Cross-buying Value	93.3%
Both	91.9%

Table 7 % of Relationships with Zero and Non-Zero Values

We observe that cross-buying does not bring a major contribution to total profit, so we sum it with value of repurchases and consider it as one output of the retention function. For the purposes of allocating the firm's resources for retention, we focus then on the resources that the firm allocates. After summing up, further analysis was carried out to find treatment for the zero values in the RMIs investment input. We investigated the hypothesis that RMIs have an impact on retention such that customers who have not received any are actually in disadvantage. It was found that the firm-customer relationships that had received any investment in the form of RMI had a higher average total value of retention purchases which include cross-buying and membership repurchases. The results of the t-test are in Table 22 in the Appendix.

Looking at this issue from a business perspective, we see that zero values do not represent missing data. We understand that the customers with zero RMIs investment that have similar value of repurchases and cross-buying with customers with non-zero investment do not share the same retention process. Therefore, we choose to compare relationships with non-zero values in the investment input separately assuming these operate under different technology. So, we solve the models for two subsets of the sample. Subset A consists of 21 customers with two inputs (RMI investment and number of discs in Top 3) and one output (Total value of retention purchases). Subset B consists of 1187 customers with one input (number of discs in Top 3) and one output (Total value of retention purchases). Descriptive statistics of the two subsets' input-output set are in Table 23.

5.3 Results

We assess the retention function on congestion and waste of resources. The waste of resources in the retention function is estimated solving model (1) in Table 3 in section 4.3. The investigation of input congestion was done by solving models (2) and (4) in Table 4 in the same section. Models

on waste were solved using PIM-DEA software and models on congestion were solved using Excel Solver. The summary of the models implemented are in the following table.

Retention Problems	Model	Inputs/Outputs	Dataset
1. Congestion	(2) and (4) in Table 4 in section 4.3	**Inputs:** -RMI Investment -Number of Discs in Top 3 of user's wish-list **Output:** -Total Value of Membership repurchases and Cross-buying	**Subset A:** Active customers by February 2009 that have non-zero RMIs investment (21 DMUs) **Subset B*:** Active customers by February 2009 that have zero RMIs investment (1187) **used only in the waste model*
2. Waste	(1) in Table 3 in section 4.3		

Table 8 Summary of models run

The results are split in five parts. The first has to do with the level of RMIs resources that actually reduce the customers' purchases due to congestion. In the second one the efficiency scores and the level of firm's resources that could be saved are presented. Third, potential increase in sales is estimated. The improvement of the retention performance is shown in the fourth part. In the fifth part we apply the idea of a customer's perspective retention efficiency using the concept of the worst practice frontier.

Results	Based on Model
Total congesting input and congested output	1. Congestion
Waste of resources	2. Waste
Sales Potential (Slacks)	
Improving efficiency of customers using Layering technique	
Customer's Perspective Retention Performance *Worst Practice Frontier by reversing inputs and outputs	

Table 9 Summary of results presented in the following sections

5.3.1 Firm's RMIs Investment Congestion

We expect RMIs investment to reduce the value of repurchases and cross-buying when invested heavily. This phenomenon is called congestion and we apply models (2) and (4) in Table 4 on Subset A to measure it. The methodology relies on the work of Cooper et al. (2001) with the exception of the restriction of the congestion on one input rather than both. This is why we use model (4) instead of (3) after solving model (2). The number of DMUs that were found congested is 10 from a total of 21. We aggregate the congesting input and the congested output for these 10 DMUs. The congesting input is the sum of the slack from model (4) that is attributed to congestion. Since all slacks were attributed by the model to congestion and none to technical inefficiency we assume that these DMUs could achieve higher output should there be no overinvestment. This additional output level is the congested output. We calculate this by getting the difference of the actual output from the targets from model (2). The congesting amount of RMIs investment is 37% of the total allocated. This means that this investment is found to have negative return instead of positive on these 10 DMUs with quality remaining as is. The value of purchases could be improved by 34% for the 21 DMUs. The amount of input congestion at the DMU level is in Table 26.

Subset A	Level (%) of Actual RMIs Investment that causes congestion	Level (%) of Actual Total Value of Repurchases and Cross-Buying that is congested
Congested DMUs	47%	55%
All 21 DMUs	37%	34%

Table 10 Congesting Resources and Congested Retention Purchases

5.3.2 Waste of Firm's Retention Resources

Efficiency scores from solving model (1) in Table 3 are estimated and results are in Figure 7 and Figure 8 for Subsets A and B respectively. The average efficiency score for Subset A is 69% and for Subset B it is 14%. Because the scores refer to different frontiers, the comparison between them is not possible. We examine each separately. Descriptive statistics of the results for both subsets can be found in Table 25.

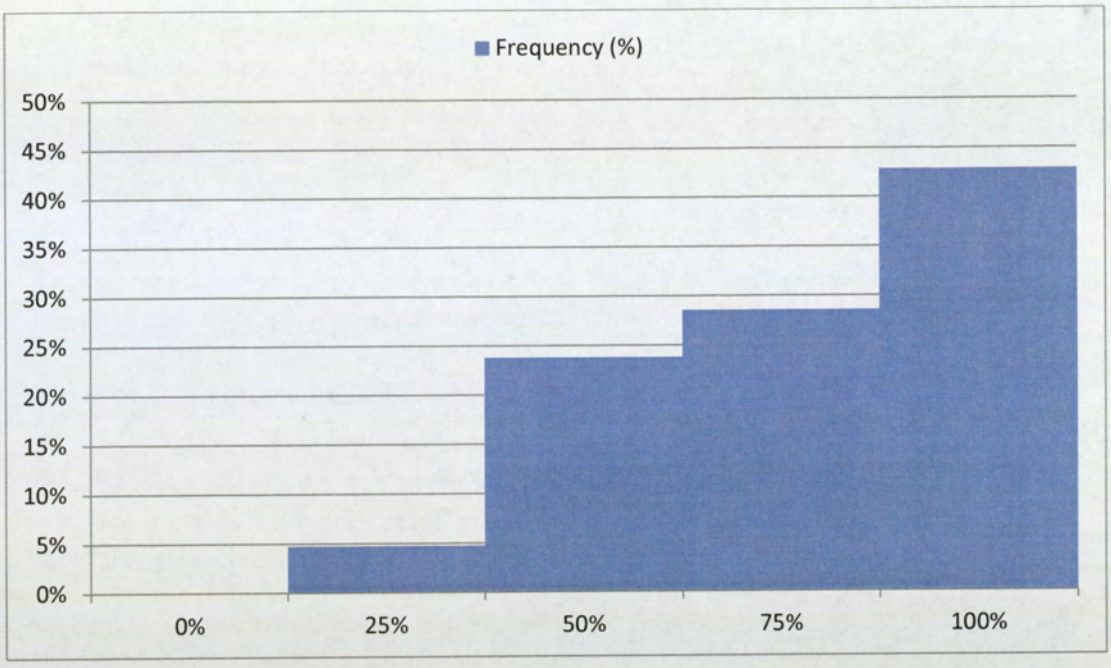

Figure 7 Efficiency Scores of the Waste model for Subset A (21 DMUs)

Subset A consists of 21 DMUs, namely customers. This is not representative of the 1208 active customers in this assessment. What we can see from the grouped histogram is that the majority of the DMUs are located close to the frontier. The worst performer has an efficiency score of 25%. The RMIs investment is examined for reducing purchases when overinvested in later section. This efficiency score does not capture this effect. The effect of the efficiency on the firm's resources is discussed in later sections.

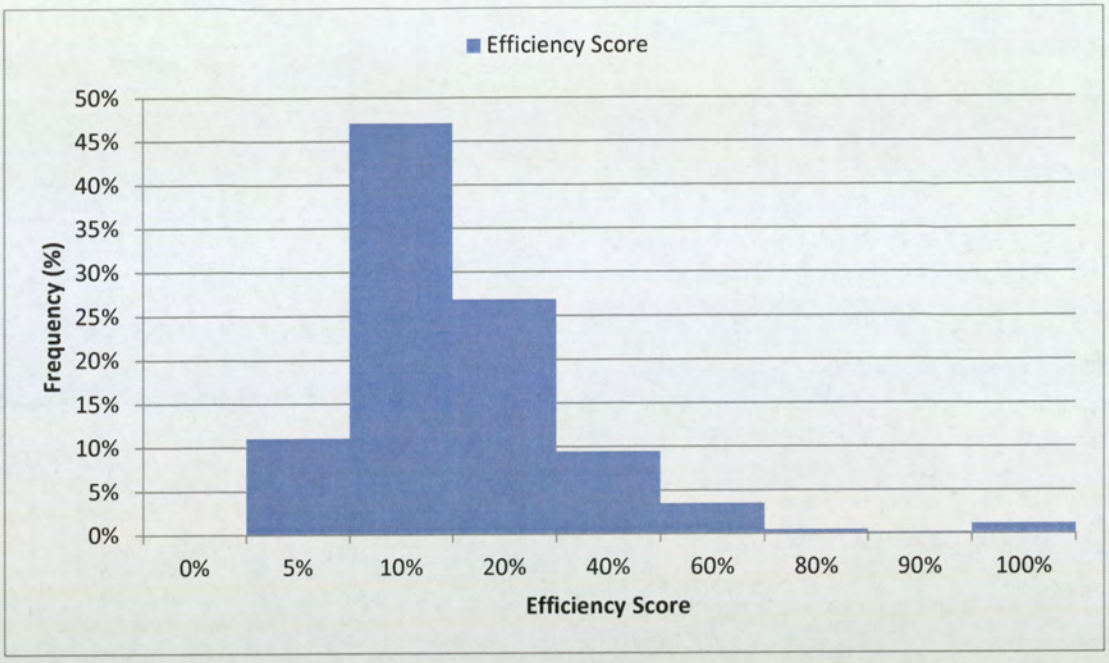

Figure 8 Efficiency Scores of the Waste model for Subset B (1187 DMUs)

The histogram of the efficiency scores of subset B reveals that the majority of DMUs are relatively low performers. Should the firm want to get these customers close to the frontier then a reduction of the single input is required which in this case is quality. Also, the number of the DMUs is large that makes the reduction on aggregate to be considerable. This prompts us to use the layering technique to create steps in between and get targets that can be considered more feasible. Before the layering technique, we show what these efficiency scores mean in terms of waste of resources.

The efficiency scores show the level of the waste. If a relationship is found efficient, that will mean that the firm has allocated relatively the minimum required retention resources for the customer's repurchases and cross-buying value as observed from the data. If a relationship is found inefficient then the input quantities found to be in excess given the output are considered waste. The total quantity of waste consists of two parts. The first is estimated from the efficiency score and is actually the difference of the radial projection of the assessed DMU from its actual levels. This reduction affects both inputs so that the value of the repurchases remains the same. There is also a possible reduction of waste that is due to slack, meaning reduction not necessarily in both inputs that may be found feasible without reducing the other input. Slack quantities are considered inputs

in excess that do not affect the production of the output. Waste is reported at the aggregated level of the retention function for RMIs investment, Quality delivered for the first subset, the second and both subsets are combined in Figure 9.

From the total amount allocated in RMIs, it is found that 43% was enough for the repurchases and cross-buying made based on the model. The rest is found to be in excess and consists of two parts. First, there is a 9% reduction that is found possible without altering the other inputs and outputs. This reduction is due to slacks. Slacks are not necessarily to be reduced, because they can act as a buffer. So, the firm may decide the level of the slacks instead of eliminating it completely according to its strategy. Second, the biggest part of the investment is the waste the efficiency score indicates. The firm will benefit the most when the waste is eliminated for both inputs.

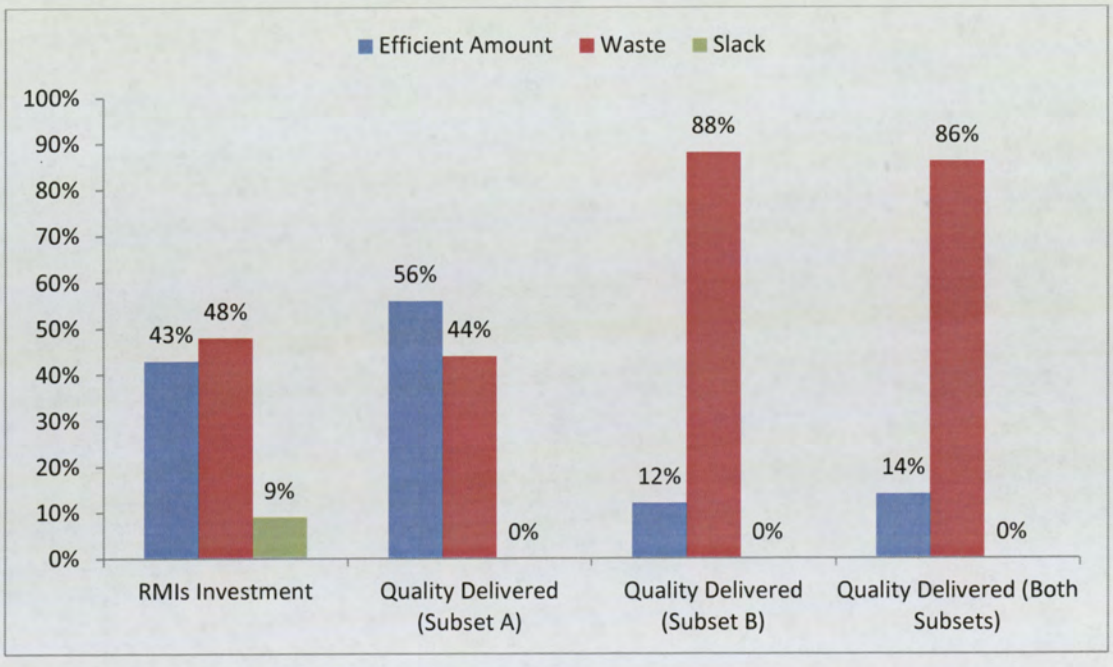

Figure 9 Allocated Resources

Quality delivered as measured by the number of discs that are in the Top 3 of the customers' wish-list is found to be allocated efficiently at 56% of the total effort for Subset A. This means that the firm could have allocated discs on the inefficient customers at a lower position. The firm, then, has room for readjusting its effort in delivering quality. The relatively low efficiency scores in subset B are resulting in identifying a large proportion of Quality delivered as waste. The 88% waste is

explained because of the fact that the efficient customers have been allocated such few DVDs in the Top 3 positions of their wish-list relative to their purchases. We calculate the total level of waste of quality at 86%. This level of waste of the quality delivered could have a great impact on the firm's management. We used layers to suggest smaller waste reductions, thus relaxing the firm's effort. In later section, we discuss such suggestions.

5.3.3 Sales potential

DEA analysis offers insights in the output side of the model as well. Estimating waste in inputs can show whether there are possible improvements in the outputs based on slacks. We find that there is room for increasing repurchases and cross-buying for both subsets. Subset B has the biggest room for improvement. Again, it is affected by the high performers in that subset as shown in the previous section.

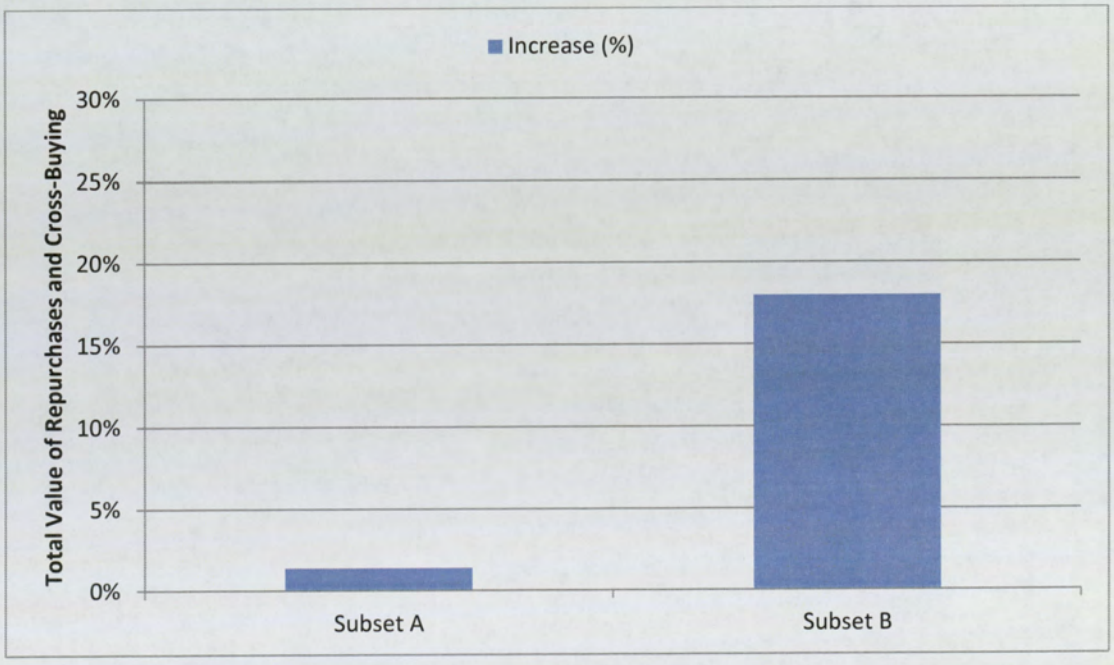

Figure 10 Increase (%) of Total Value of Repurchases and Cross-Buying due to slacks

The slack in the outputs is untapped sales potential. Although sales are not considered an internal resource that the firm can decide to utilize or not, its level of slacks can have managerial use. This sales potential can be used from the firm to set sales targets for each customer. Even if the firm

decides to allocate the same resources as in the assessed set it can still assume such increase possible and pursue ways to achieve it.

5.4 Improving retention performance

The next goal of the analysis is to show how the retention performance can be improved using DEA. We use the efficiency scores and the waste as estimated in section 5.3.2 to make our suggestions on resources allocation at the customer level. The improvement is done in two stages. First, the retention performance is improved by reducing the waste. The firm is advised to cut down its investment on the inefficient customers since they are expected to generate the same amount of purchases but with fewer resources. Second, retention can be further improved by increasing productivity by increasing the scale of investment and hence return on the resources. The highest return is on the part of the frontier where local CRS hold. The firm can reach this point by investing the necessary amount of resources on the efficient customers so that they move to the most productive scale size. For the firm to make such decision, it is necessary to know the impact of this tactic on the total revenues. We make such estimation for the efficient customers and for the firm at the aggregate level.

The level of inefficiency shows the minimum resources that could be used for the same amount of purchases plus the corresponding slack if any. The efficiency scores have shown that almost half of RMIs investment and 86% of Quality delivered are considered waste. Suggesting such a decrease in resources invested may be found undesirable due to the size of the change in the resources. The layering technique helps to find targets that are closer to the actual levels of resources. We applied this technique on both subsets. The first subset consists of those 21 DMUs that have received some level of RMIs investment. When a DMU is found efficient, it is removed from the subset and the score from the previous evaluation is used to get the targets. There are 4 layers in total. The first layer consists of the efficient DMUs that form the frontier for the whole sample. The DMUs found efficient in the second run have already been set the closets targets possible from the first layer. So the layering technique affects the targets of the rest of the DMUs. Although the targets from the

layers do not render inefficient DMUs efficient as per the whole set of peers, they are still closer and hence more feasible for the firm. The layers in Subset B are 46, due to the higher number of DMUs in the assessment. Again, the efficiency scores that have increased refer to the inefficient customers of layer 3 and onwards. This results in setting less demanding targets to improve efficiency as opposed to setting targets based on much better performers. The use of layers renders smaller distances between inefficient customers and their (new) peers. This translates into higher efficiency scores and hence closer targets. We show how the layers affect targets at the customer and the aggregate level.

The layering technique allows for intermediate frontiers to be created. In Figure 13, we show the frontier of the cross-section assessment, named layer 1, the second layer that is constructed after removing the customers form layer 1 and the seventh layer which is the last layer against which customer ID 22188 is found inefficient. This frontier then gives the closest targets for improvement. There layers between 2 and 7 and the customers that form it are omitted to make the figure more easy to understand. Target 1 is the virtual unit the input and output of which are the targets of the cross-section analysis for customer ID 22188. Target 2 refers to the input and output that the customer should have after removing the efficient units of layer 1. Although these targets are still valid, removing efficient units sequentially allows getting to the closest target, which for this example is on layer 7.

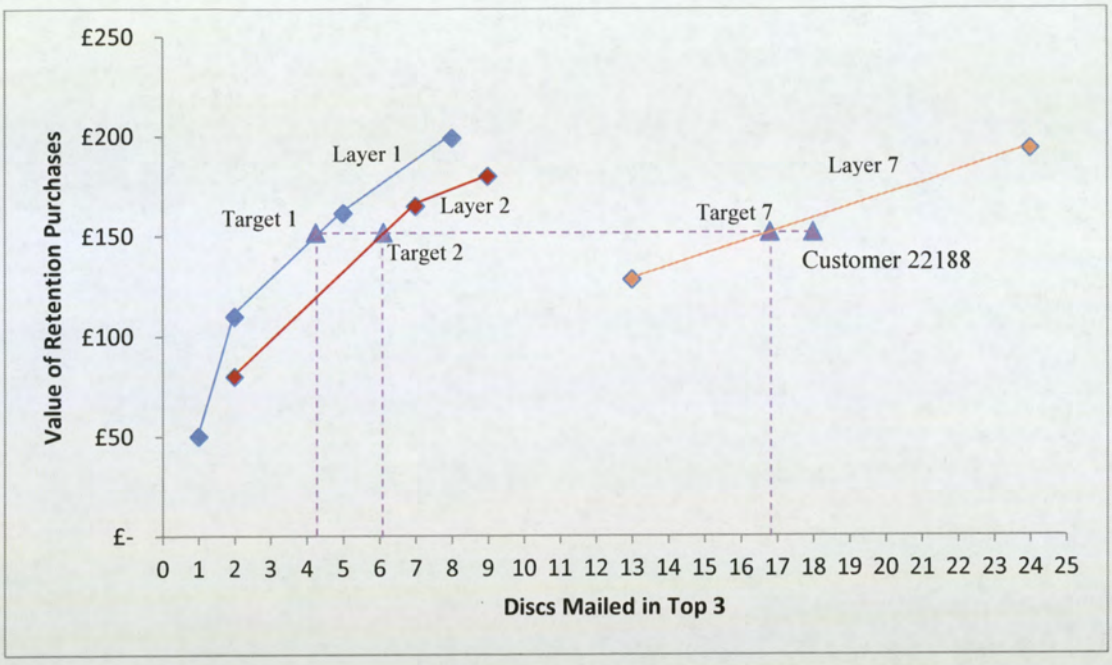

Figure 11 Layering Technique Targets for DMU 22188

We select two inefficient DMUs one from each subset to show how their individual targets are changed. In Table 11, customer ID 23542 targets are set closer to the actual levels when the layering technique is used. After removing the first layer, the second frontier gave the closest improvement targets for the inputs. The level of repurchases is the same because no slack is found. This means for the firm that it can expect £187.74 worth of membership repurchases and cross-buying for 38 DVDs in the Top3 of the wish-list and £10.81worth of loyalty and recommendation rewards.

Subset A DMU: 23542	Efficiency Score	Value of Retention Purchases (Output)	Quality (Input)	RMIs Investment (Input)
Actual	-	£187.74	53	£15
Cross-Section Target	62.87%	£187.74	33	£8.88
Layer-Minimum Effort Target	72.05%	£187.74	38	£10.81

Table 11 Targets from Cross-Section and Layers for DMU 23542 from Subset A

The same is true for customer ID 22188 from the second subset. We show how the layers work for this individual in Figure 11. In this case we have only one input and the same one output. Based on the comparison, customer ID 22188 would become efficient if for the expenditure of £151.81 due to retention, the discs mailed to her from the Top 3 positions would be 4 instead of 18. Such a

suggestion may be considered undesirable. In this case the layers removed were 6. The closer targets using the layering technique are in Table 12.

Subset B DMU: 22188	Efficiency Score	Value of Retention Purchases(Output)	Quality (Input)
Actual	-	£151.81	18
Cross-Section Target	24.69%	£151.81	4,44 (Target)
Layer-Minimum Effort Target	94.37%	£151.81	16,9 (Target)

Table 12 Targets from Cross-Section and Layers for DMU 22188 from Subset B

We now compare the efficiency scores and the targets for the two inputs from cross-section and layers sets for the affected DMUs at the aggregate level. The measures as percentages of the actual levels for each input are calculated. We find that targets are closer to the actual levels and hence sacrificed by 30% for RMIs and 76% for Quality. In practice, this means that reductions suggested by the model are smaller and the firm can follow these as guidelines for performance improvement as opposed to the initial targets that may disrupt the retention function more than desired. The aggregate effect of this technique on the targets to be reached is shown in Figure 12. The relaxation is evident and that allows the firm to make smaller changes in its resources allocation strategy.

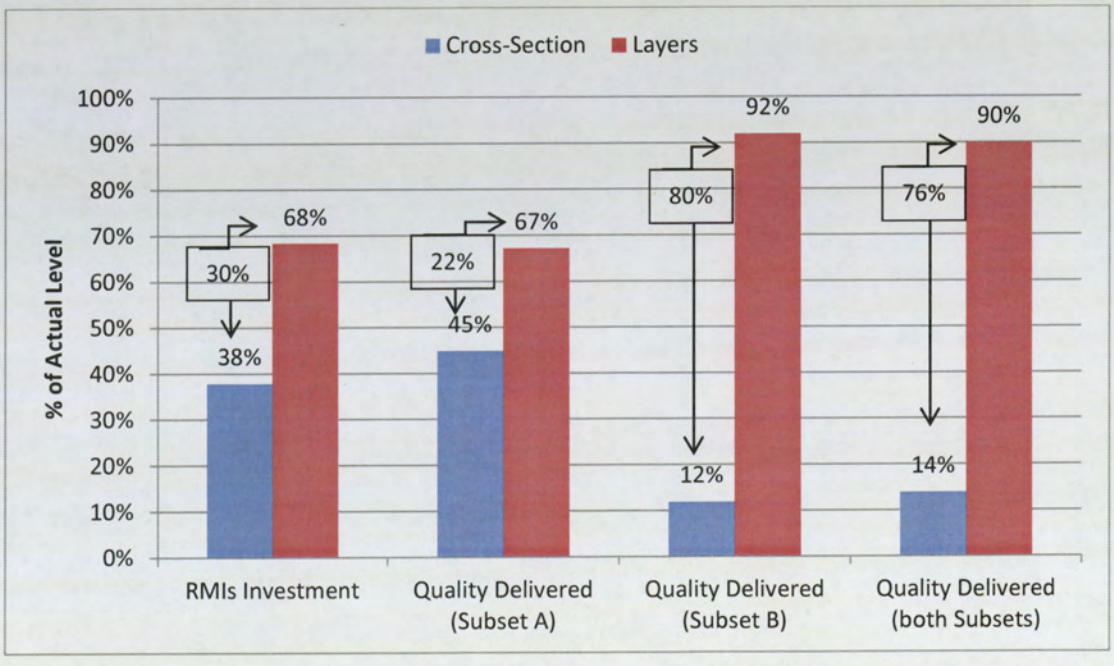

Figure 12 New Targets (Layers) and Initial Targets (Cross-Section) for Inefficient Customers

The frontier of best performers is constructed on the assumption of non-constant returns to scale. This means that there are customers that are found to be operating locally at IRS, that in turn are expected to return more in proportion to the resources allocated to them. Should the firm were to act upon this information only on efficient customers then it could use it to prioritize its increase of resources invested. As discussed earlier, DMUs operating locally at IRS can take advantage of proportional increases in their inputs producing more than proportional increases in output. The customers that are found to be operating locally at CRS are suggested to be second in priority and those operating at DRS to be the last of the efficient customers to receive further investment.

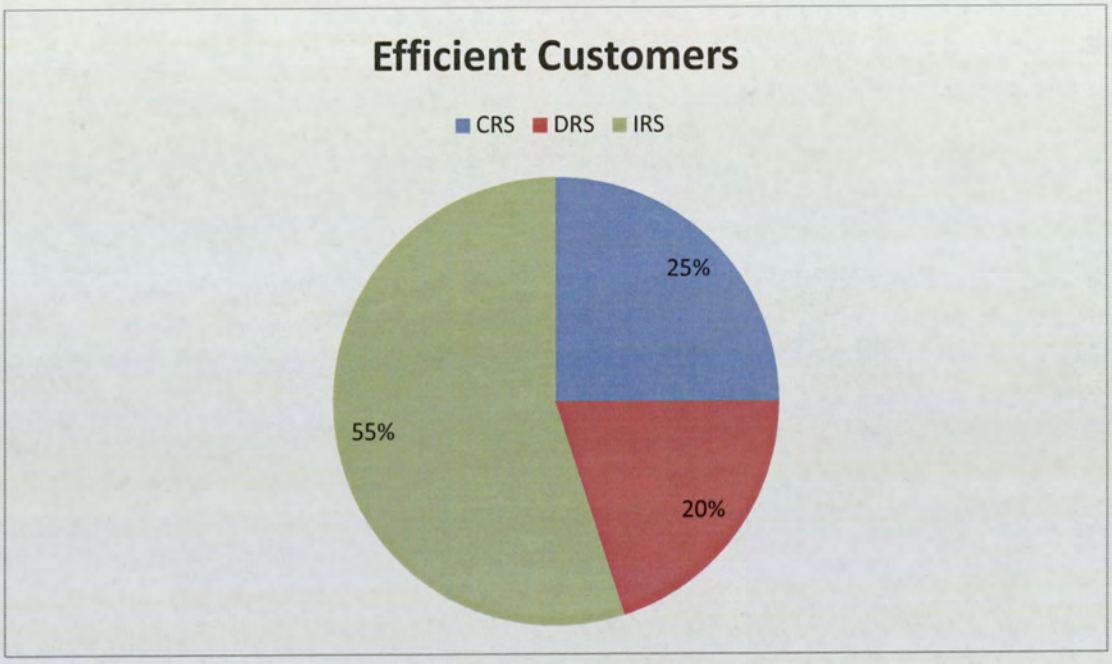

Figure 13 Local RTS for Efficient Customers of Subsets A and B

In addition to the use of local RTS, DEA analysis can set specific targets for the resources allocated and the corresponding sales of the efficient customers. These targets are based on the concept of MPSS, which is the part of the frontier where DMUs are operating under CRS. Each efficient customer's targets are set based on that part of the frontier. Customers found to be operating at IRS are suggested to have more resources invested on them while those operating at DRS should have these decreased. Based on the MPSS input levels, the corresponding output levels are derived. The identification of local RTS and the estimation of MPSS input-output levels are done using PIM-

DEA[14]. The actual and MPSS input-output levels for an efficient DMU that is operating at local IRS are shown in Figure 14.

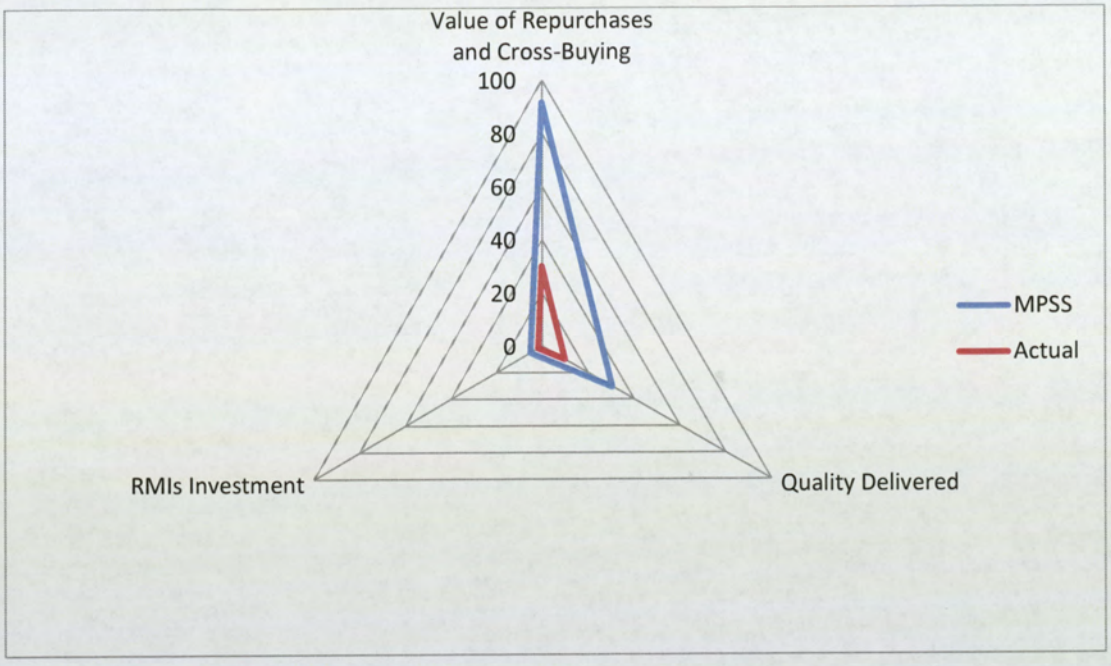

Figure 14 Actual and MPSS inputs and output levels for DMU 34855 (Subset A)

The firm is suggested to increase its resources on this relationship as it is expected to produce higher outputs proportionally and still be efficient. We aggregate the effect of achieving MPSS targets for all efficient customers at the firm level in Table 13. We find that for the efficient customers in Subset A an increase in both inputs and the output is possible and beneficial for the firm. On the other hand, the aggregate change for efficient customers in Subset B for quality is negative. This is because it is driven proportionally by the customers found to be operating under DRS and hence set MPSS targets for the inputs to be lower than the actual ones, while the revenues are to be increased for both subsets.

Efficient Customers	Change (%) from Actual to MPSS level

[14] For more details please see Thanassoulis et al. (2008)

	Quality Delivered	RMIs Investment	Total Value of Repurchases and Cross-Buying
Subset A	+22%	+28%	+20%
Subset B	-50%	-	+19%

Table 13 Changes (%) on Actual levels to achieve MPSS

We perform a final calculation to see whether the firm will benefit in terms of revenue from its retention operating at the most productive scale size or it should pursue efficiency only. The reason behind this is that the absolute level of the retention revenue at MPSS may be lower than the efficient level, although most productive. In essence we compare the efficient frontier targets against the MPSS targets of the waste models for the whole customer base. The total revenue is aggregated at efficient and MPSS levels for both subsets. We find that the firm will suffer a loss in revenue for subset A of 14.4% of the actual revenue should it pursue highest productivity. When it comes to subset B the firm will earn an extra 41% of its actual revenue again by going for higher productivity. Ideally, the firm can increase its revenues by aiming at efficiency targets for subset A and MPSS targets for subset B. In practice, the number of DMUs in subset A is negligible compared to that of subset B. So, the firm can benefit by trying to get to MPSS levels as a one-size fits all strategy.

5.5 Efficiency from the customer's perspective

We solve model (1) for both subsets as in the sections before but we reverse the inputs and the output to get retention performance frontier and efficiency scores from the customer's perspective. We select an input orientation for the efficiency assuming the customers want to use the least possible resources given what they receive from the firm, which are purchases and quality respectively. This way, the customers we identify as efficient are performing best from their view of the exchange. These are found to be retained in the relationship with more resources and less repurchases and cross-buying possible than the rest. The firm can use this analysis as a way to identify the worst retention practices, which are located on the frontier. We calculate the efficiency scores and the waste of customers' resources on aggregate and at individual level using two examples. We also show the two frontiers for subset B in Figure 15. This way we show the difference

between the two perspectives as best against worst practice frontiers and the meaning of the latter for the firm.

Subset A consists of 21 DMUs and the average efficiency score is 63%. The 1187 DMUs in Subset B have an average efficiency score of 22%. Descriptive statistics of the efficiency scores are in Table 25 in the Appendix. These efficiency scores are translated into customers' purchases that could have been saved given the firm's effort to retain them. We also report the slack that is not zero in the outputs side. This can be interpreted as increase in quality and RMIs that the customers could enjoy based on the comparison. An aggregate view of the efficient, waste and slack levels is in Table 14.

		Efficient Amount	Waste	Slack
Subset A	Total Value of Repurchases (Input)	62%	38%	0%
	Top3 (Output)	-	-	18%
	RMIs (Output)	-	-	9%
Subset B	Total Value of Repurchases (Input)	18%	82%	0%
	Top3 (Output)	-	-	15%

Table 14 Waste of Customers' Resources and Slack on aggregate

In the two following examples we show what the efficiency means for two customers. The first one taken from Subset A is found to have been able to make smaller purchases around £25 and at the same time have 8 more discs from his Top3 be allocated to her. A similar interpretation is given for the customer taken from Subset B. We present the targets in Table 15. Such reallocation of resources is not feasible since customers are not aware of such analysis. However, we show the targets for better understanding of the worst practice frontier concept.

	Efficiency Score	**Value of Retention Purchases (Input)**	**Quality (Output)**	**RMIs Investment (Output)**
Subset A DMU: 33348				
Actual	-	£74.94	27	£15
Target	67.19%	£50.35	35 (Slack)	£15
Subset B DMU: 33222				
Actual	-	£7.99	11	-
Target	61.2%	£4.89	15 (Slack)	-

Table 15 Targets of Customer's perspective Waste model at individual level

The single-input single output case of Subset B allows for the frontiers to be graphed in Figure 15. The top piecewise convex line shows the frontier of best practices, while the bottom one shows the worst practices as per the firm's interest. The latter is also the frontier of best practices as the customers would perceive the retention function. DMU W is found inefficient against both frontiers. Its projections on the frontiers that minimize the input for each process are W_1 and W_2. The coordinates are the targets for W.

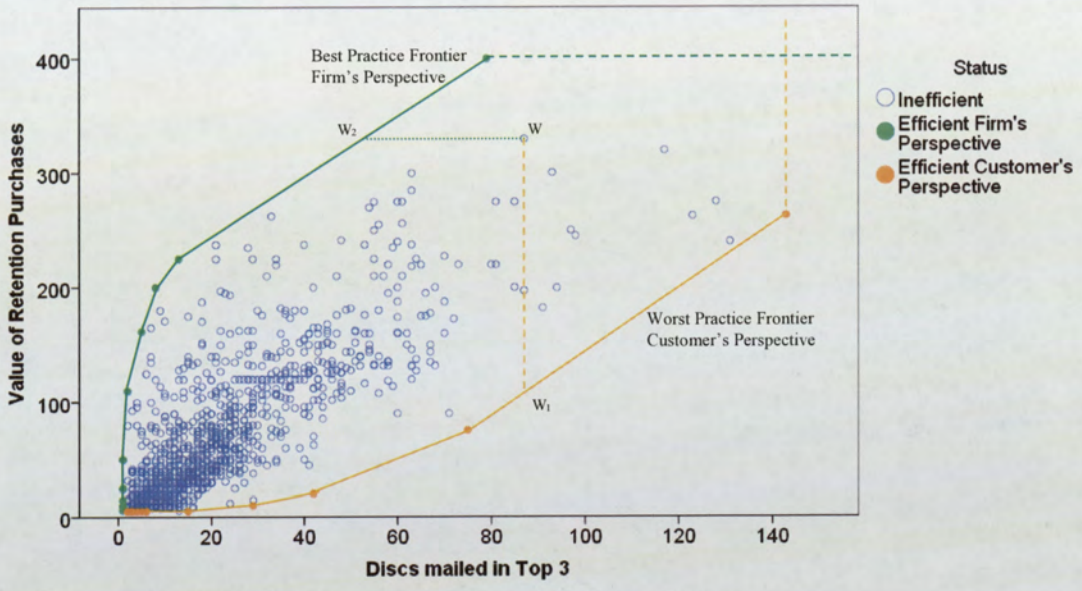

Figure 15 Best and Worst Practice frontier for Subset B

The worst practice frontier above can act as the minimum sales target for the firm's current resources allocation strategy. The projection of each customer on the worst practice frontier gives a minimum revenue target given the actual resources invested. This can be interpreted then as the least acceptable revenue target based on the benchmarking of the customers. We still use DMU W as an example for demonstration. The levels of inputs and outputs of W observed and projected on both frontiers are in Table 16. The target of 52.58 discs is the lowest that the firm should allocate for the £329.78 value of purchases. From the worst practice perspective, given that the firm still allocates 87 discs from the Top 3, the minimum worth of purchases it should set a minimum goal of £108.01.

Subset B DMU: W (21753)	Efficiency Score	Value of Retention Purchases	Quality
Actual	-	£329.78	87
Target (Firm's)	60.43%	£329.78	52.58
Target (Customer's)	32.75%	£108.01	87

Table 16 Actual and Target levels for DMU 21753 (W) for both frontiers

The best and worst practice frontiers can help the firm identify best and worst performers. The former identifies the best performers that set the standards for the rest, while the latter identifies the least expected outcome given the retention effort in terms of resources remains the same. Further investigation of these for any relationship with other customer characteristics may help the firm make better marketing decisions. We make such effort in the next chapter.

5.6 Summary

We assess retention performance of an online DVD rental company. The firm is assumed to run the analysis on its active customers each time to make relevant adjustments in its resources allocation. The inputs and outputs of the conceptual model are operationalized for this particular case study. The issue of zero values comes up for RMIs investment and cross-buying. The former is an input and is treated by splitting the customers into Subsets A and B as they are assumed to operate under different technology. The latter is treated by summing it with the value of repurchases. A total of 1208 DMUs are analyzed, 21 in Subset A and 1187 in Subset B.

We look for congestion of the RMIs investment, as it is found that overinvestment can reduce the purchases. We report the allocated investment that is congesting the value of purchases and also the congested output. We estimate the level of waste for the firm's resources due to inefficiency. We also estimate the level of sales that could have been increased from output slack. The next step is to suggest actions stemming out of the DEA analysis. The firm is advised to invest on efficient customers based on the concept of the most productive scale size. Then we show how the layering technique can be used to divest from the inefficient customers by making smaller moves. Finally, we apply the concept of the worst practice frontier to show how the retention performance is viewed

from the customer's perspective. Although the customers cannot run the analysis, the firm can use this assessment for marketing decisions as shown next.

6 Efficiency and CRM

In this chapter we explore the relationship between efficiency scores and customer information. We do so in the context of a CRM analysis, that aims at discovering patterns and insights that the marketing team can make use of. For that reason, we focus on the metrics of profit and duration and membership information like the acquisition method and membership levels as well as churn. Profit is approximated using the cost per disc mailed that management advised. The duration is the time between the date of registration and the date of cancellation or the latest date recorded in the dataset. We use the same sample as in the retention performance assessment except for performing the analysis on Subset B only since it is big enough for conclusions to be made. These are the customers that never got any RMIs investment. We conclude our analysis with a churn model that is a common task in the marketing management agenda.

6.1 Efficiency and Customers

We look at associations of the efficiency scores and customers' characteristics. The profit per customer and the duration of her lifetime are important customer metrics for firm growth. Since, it is a subscription-based model and the cross-buying purchases are scarce we expect a high correlation between profit and duration. We provide the Pearson correlation matrix in Table 28 in the Appendix**Error! Reference source not found.**. The correlation of duration and profit is supported. he efficiency scores from both perspectives and profit have a weak linear correlation, with the firm's being positive and the customer's being negative. There is also weak correlation between firm's perspective efficiency and duration. There is none between the customer's perspective efficiency and duration. These findings indicate that there are customers that although being retained more efficiently, hence with less quality delivered than others they can still be more profitable. An intuitive view of these relationships would consider that the worse a customer is treated the less profit she will generate. So, this is an opportunity for the firm to consider a segment of customers whose purchases are less affected by quality delivered and investigate it further. In the previous

chapter, we advised the firm to allocate resources on efficient customers based on MPSS. This can be particularly useful for high profit and efficient or high efficiency customers.

We also examine the relationship between the efficiency score, profit and whether the customer was acquired through some promotion scheme. Customers that were acquired on promotion are found to have lower average firm's perspective efficiency scores than those that were not acquired on any promotion. The customer's perspective efficiency score is higher for those that were acquired through some promotion. The differences are shown in Figure 16 and are supported by the t-test performed in Table 29 in the Appendix. The subscribers that benefited from a promotion scheme still get more discs in the Top 3 positions of their wish-list than the others. For the current case, we interpret this as better treatment in terms of quality. Although, the firm has allocated more resources on acquisition and retention on these customers, the average profit is lower. The firm can look to reduce quality from the customers acquired on promotion and the layering technique can help in this task. Divesting gradually should increase efficiency and this can help the firm free up resources from low profit customers.

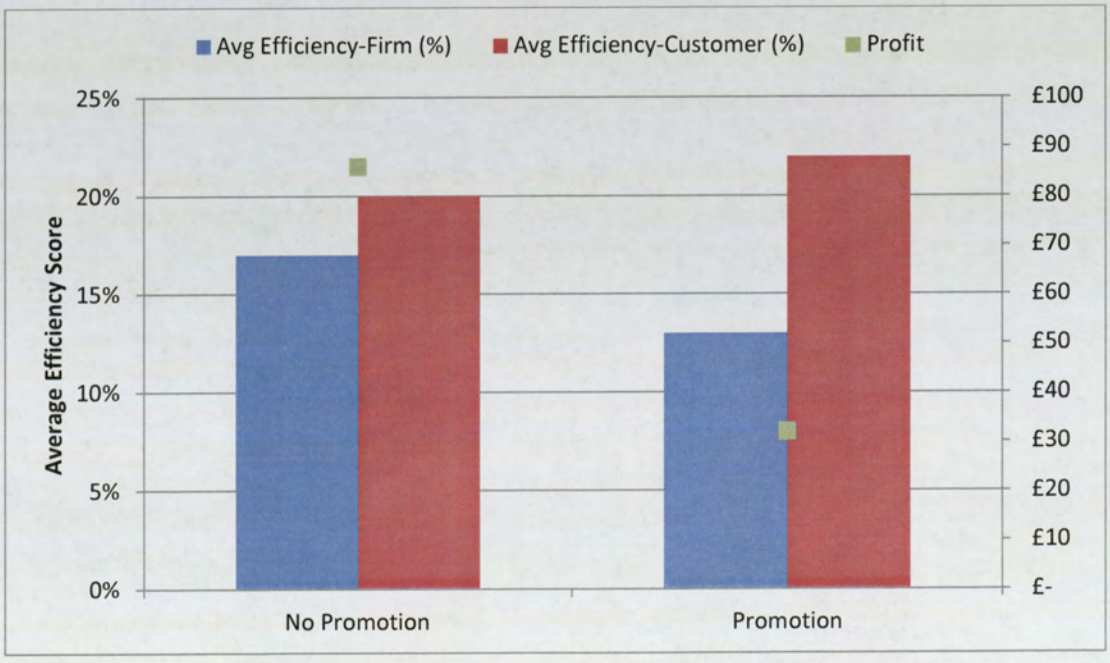

Figure 16 Efficiency score based on Acquisition (Promotion) for both Subsets

The last relationship we investigate is that of the efficiency scores from both perspectives and the subscription level with which the customers have first subscribed. We coded these so that the levels are ranked based on price that reflects the "richness" of subscription package. Level 1 is the cheapest and targets users that watch less often than others and the richest is level 8 for heavy consumers. In the current dataset the richest recorded is level 7 from the 8 available. The ANOVA tests showed that the average scores and profit are different across levels and results are in Table 30 in the Appendix. For this reason we look at the averages of the efficiency scores and profit per subscription level in Figure 17. We find that customers that first subscribed in level 5 have the highest average profit and high average efficiency score (firm's perspective). This combination of profit and efficiency is of particular importance for the firm as shown earlier. Although, this does not mean that these customers are still in this membership level, the firm can use this insight as an alert for customers of value in the future.

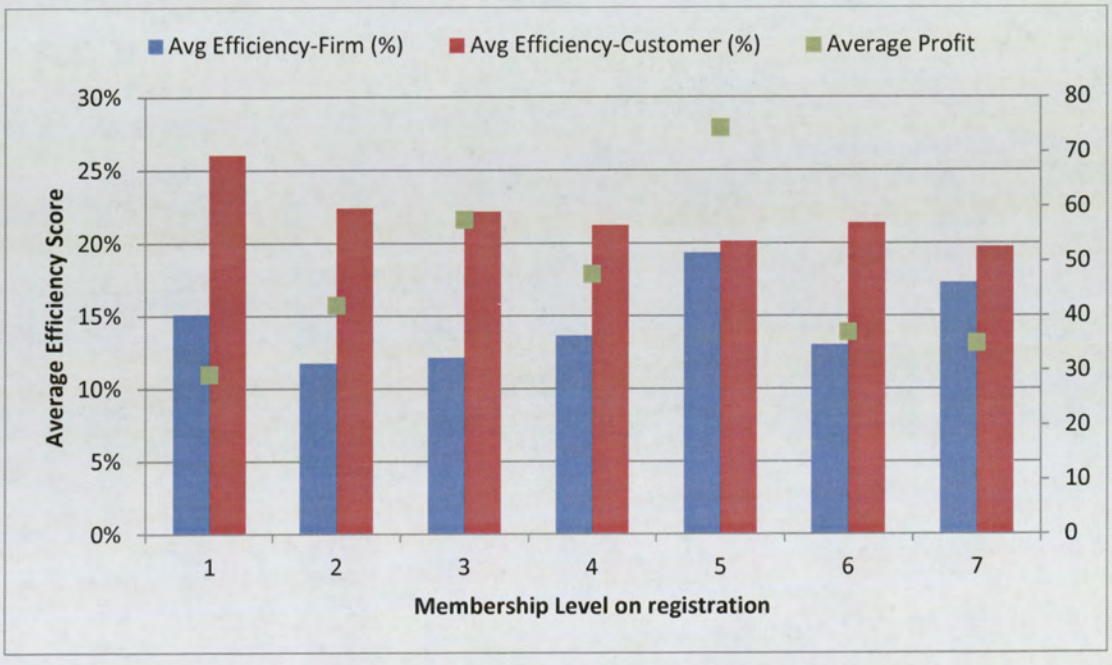

Figure 17 Efficiency score based on Membership Level (1=smallest...7=biggest) for Subset B

Efficiency scores and customer characteristics can be further explored for pattern discovery. Analysis at the segment or individual level can be carried out. The analysis so far intended to show the possibility that the retention efficiency can bring additional information that can be interpreted

accordingly. High profit high efficiency customers can be a segment to further invest on using the MPSS concept. On the other hand a low efficiency low profit segment can be prioritized for divestment. The analysis carried out in this chapter was static. Looking at customer retention performance and customer behaviour across time could bring further insights on the retention function. Next we show how the efficiency scores can be used in churn modelling.

6.2 *Efficiency and Churn*

An important CRM task for subscription-based businesses is the estimation of the probability of churn. We show how the efficiency score is included in this task along with other customer data. Research has shown that the selection of predictors can follow various paths (Neslin et al. 2006). One is to follow some theoretical paradigm on customer retention; another is to use all available data and one that combines both. We estimate the probability of churn using FCRE scores and a set of covariates that makes sense in marketing management terms. This set includes usage data, as well as membership data (Hadden et al. 2005). We apply a survival function estimated using Cox Proportional Hazards that has been used on membership business models and is discussed in section 6.2.1.

The covariates used for estimating churn are grouped in the table below:

Group	Name	Description	Codename
Membership	Membership level on account creation	This is the first membership level the subscriber chose. Coded as 1-8. The higher the level the higher the price.	CreateLevel
Acquisition method	Promotion on membership creation dummy	A dummy that indicates whether the customer used a promotion to start his account	PromCreate
	Gift Subscription Redeemed	A dummy that indicates whether a subscriber redeemed a gift subscription purchased by another person to open his account	IsGift
Quality of Service	Disc Problems Solved	The number of problematic discs that were taken care of by the firm	DVDProblemSolved
Usage patterns	DVD from TV Series	Dummy for the disc being a TV series	Series
	Membership Level changes	The number of times the membership level has changed	MemChange
FCRE	FCRE scores (Firm's perspective)	The most recent efficiency score from the waste model	Efficiency_score_Firm
	FCRE scores (Customer's perspective)	The most recent efficiency score from the worst practice waste model	Efficiency_score_Customer

Table 17 - Churn estimation covariates list

We aim at showing a way to operationalize both the efficiency assessment and the probability of churn estimation. The covariates except for the efficiency score and the dummies are cumulative in this case across each customer's lifetime. Another option would be to consider averages per billing cycles, but that was not technically possible with the current dataset. Cumulative data has been used in churn modelling (eg Coussement and Van den Poel 2008). Aggregating customer data to get the covariates is straightforward operationally. When it comes to the efficiency score, we are interested to see whether the score of the most recent assessment can signal churn. We use the firm's perspective efficiency score as in 5.3.2, because this score shows the waste of resources the firm wants to reduce. For that reason, we have assumed that the firm assesses its active customers periodically and uses this efficiency score as a covariate in the survival function. In this case study,

we assume the firm assesses its active customers at the end of each calendar month. So, we investigate if and how this efficiency score affects the probability of churn. The sample selection criteria of least repurchases and least discs mailed without problems for the efficiency assessment that have been applied in Chapter 5 are applied in this task as well. This makes sure that behaviour that is as typical as possible is captured. On the other hand, this may exclude customers that do not meet the criteria of efficiency assessment. These customers would actually be the free-trialers that are not of interest in this retention function, rather in some conversion strategy that is out of the scope of this research.

Example of Customers' Lifetimes included in the model	Status	Covariates (excluding Efficiency Score)	Efficiency score from Assessment in
Customer A	Active (February 2009)	Aggregate up to most recent record	January 2009
Customer B	Churned (February 2009)	Aggregate up to most recent record (record of churn)	January 2009
Customer C	Churned (November 2008)	Aggregate up to most recent record (record of churn)	October 2008

Table 18 Illustration of rules of customers' data used in the churn model

We want to use the efficiency score of the most recent assessment that is assumed to take place at the end of each calendar month. So, if a customer churned in February 2009, then the efficiency score used comes from the January 2009 assessment. For that reason we assessed the performances of the customers for each month for a 12-month period using the same filtering rules as in Table 5 on page 58. We use the efficiency scores of the most recent assessment. So, the sample consists of active customers by the end of February 2009 and customers that have churned sometime between March 2008 and January 2009. Next we present the Cox Proportional Hazards model and finally the results of our churn model.

6.2.1 Cox Proportional Hazard Model

The newest churn prediction technique includes the notion of hazard and survival functions borrowed from medical research. These functions predict the probability of survival or hazard (death) of a subject conditional on time. They are used in cases of left- and right-censored data,

where the knowledge over subjects' condition is unknown before and after certain period of time, e.g. outside the period of a study. What follows is the introduction to this concept up to today's Cox Proportional Hazard model applied in membership cases.

The relationship between the probability of survival and the probability of hazard is the following:

(1) $h(t) = \lambda$ if and only if $S(t) = e^{-\lambda t}$ (Kleinbaum 1996)

$h(t)$ is the hazard function for a given time t
λ is the probability of the hazard
$S(t)$ is the survival function for a given time t

The Kaplan-Meier method estimates the probability of survival non-parametrically. It is more practical than (1), but is not case dependent. The formula is shown:

(2) $$S(t) = \frac{\sum Customer_j(t_i \geq t)}{\sum Customer_j(t_i \geq t) + Churned\_Customers_t} \qquad j=1...n$$

$S(t)$ is the survival function for a given time t
$\sum Customer_j(t_i \geq t)$ is the sum of the customers that have survived the time t as in $S(t)$

The probability that is derived from (2) does not allow for possible covariates that affect churn to be accounted for. This is solved by the Cox Proportional Hazard function (Cox 1972). The hazard function for each customer j with X covariates is as follows:

(3) $h_j(t) = h_o(t)e^{\beta X_j}$

The individual hazard function consists of the baseline hazard function $h_o(t)$, which is common for all the subjects and the effect of the covariates $e^{\beta X_j}$. X_j includes the covariates of churn that the modeller investigates. We used SPSS to solve the model.

6.2.2 Results of the model

The results show that less expensive membership levels on subscription have smaller effect on churn. The customers acquired on some campaign or through gift subscription are more likely to cancel than those who have been acquired organically. Hazard is reduced by solving problems with discs. Renting DVDs that are part of a TV series and making changes to the membership level are signals of retention. Customers having smaller efficiency score than others in their most recent assessment are more likely to be retained. A summary of the effect of the covariates is found in Table 19 and numerical results in Table 31 in the Appendix.

	Effect of covariates on probability of churn	
Membership Level on Account Creation	+	The richer the subscription package the bigger the churn hazard
Promotion on membership creation dummy	+	The customers acquired on promotion have 2.6 times higher probability of churn than those who were not
Gift Subscription Redeemed	+	The customers that have redeemed a gift subscription are twice as likely to churn than those who have not
Disc Problems Solved	-	For every problem solved the hazard of churn is reduced 12.8%
DVD from TV Series	-	Each DVD mailed that is part of a TV series reduces the hazard of churn by 0.06%
Membership Level changes	-	Each time a customer is changing her membership level the hazard of churn is reduced by 10.5%
FCRE Score in calendar month before churn	+	A 1 percentage point difference in the firm's perspective efficiency score makes the customer 1.01 times more likely to churn.
	+	A 1 percentage point difference in the customer's perspective efficiency score makes the customer 1.02 times more likely to churn.

Table 19 Summary of effects of covariates on the probability of churn

The results can be used for flagging potential churners. There are further insights that the firm may take into consideration. It can promote smaller subscription packages to new prospects. This way it can still promote its service and reduce the negative effect on retention of the newly acquired customers. The firm can also encourage customers to adjust their membership level to their current needs. Its existing customers can be incentivized to include TV series in their wish-list. Finally, it is straightforward that any problems with discs mailed should be treated.

When it comes to FCRE scores, the effect on churn is the same for both perspectives. The higher the efficiency score either from the firm or the customer's perspective, the higher the probability to

churn. The score for each customer comes from the most recent assessment as explained earlier, which makes the FCRE scores be used more as a signal of churn rather than an explanatory factor. Should one try to generalize based on the results of FCRE from both perspectives would find that it makes sense for customers with few resources invested in them to be more prone to cancel their subscription. However, it does not make sense for the customers to be more likely to churn when more resources are invested to them. For the purpose of estimating the probability of churn the scores can be used as predictors, although no theoretical interpretation can be made on the relationship between the scores and churn when both are modelled together. Further investigation that includes different techniques and different time windows of assessment may make this relationship more clear.

6.3 Summary

We included FCRE scores from firm's and customer's perspective in analysis that included customer information. Uncovering patterns in customer data is a common practice in marketing. New segments and opportunities are identified for targeting and differentiating the current strategy. We also considered a churn model that is important in subscription-based models. We present findings that have been brought up in this particular case.

We found that there are customers whose profit seems less affected by quality. These customers need to be further examined to see what may be their retention drivers. A finding that is supported by the customer data analysis and the churn model is that customers not acquired through some promotion scheme are less prone to churn. These customers have a higher average profit and have received lower ranked discs. The firm should focus more of its efforts on them. We also took into consideration the membership level on subscription. Customers subscribed on level 5 have a higher average profit, higher efficiency from the firm's perspective but are more prone to churn than the customers in less expensive packages. These customers are valuable, so the effect of the membership level on churn should be outbalanced by incentivizing TV series for example that has the opposite effect. Finally, there is no clear relationship between the efficiency scores and churn. Although, the

effect of the firm's perspective FCRE is intuitive, the customer's perspective one is not. For this reason, we advise that the scores are used as signals of churn, rather than drivers that explain the phenomenon until further research is done.

7 Conclusion

We conclude the thesis by providing a summary of the process and the results, a discussion of the implication of FCRE for the firm, a presentation of the limitations of this research as well as suggestions for future work.

7.1 Summary

FCRE was introduced and developed in this thesis. The research tries to answer the question of how can the firm allocate its resources on customers for retention more objectively, when these resources are not necessarily non-monetary. Retention is influenced mainly by investment in relationship marketing instruments (RMIs) and quality that result in customers' repurchases and cross-buying. The non-monetary nature of quality is not treated in existing methods as opposed to the investment of relationship marketing instruments. We pursue a solution in the marketing productivity context applying the frontier-based relative efficiency concept. Marketing productivity is estimated at the firm or branch level and we extend our research to the customer level. So, the frontier is constructed by a subset of the relationships that are found to perform better than the rest. The frontier allows for the measurement of the efficiency by projecting the relationships on it. The technique used to construct the frontier and get the efficiency scores is DEA. It is a linear programming method that allows for multiple input-output settings to be handled along with the assumption of a black box process. In this case the inputs are quality delivered and RMIs investment and the outputs are repurchases and cross-buying. We give the following definition to FCRE.

Firm Customer Relationship Efficiency is the relative measure of the performance of the firm's retention function. The efficiency refers to the process of allocating resources on each relationship for the purpose of increasing retention that are transformed into customer's repurchases and cross-buying.

The retention function is expected to suffer from waste of resources from smaller return and congestion from overinvestment in RMIs that leads to negative return. We estimate the waste by

solving a DEA model that assumes non-constant returns to scale and get radial efficiency by contracting the inputs. So, we construct a frontier of best practices that require the least inputs given the outputs. Waste is attributed to inefficiency. Congestion is estimated based on the CTT approach. In this approach the congestion is part of the inputs slacks of the output oriented non-constant returns to scale model. We modify it so that only RMIs are allowed to cause congestion as it has been found to reduce repurchases when overinvested while quality has not. We proceed further in applying a layering technique to allow for gradual improvement in waste reduction. Sequential layers of efficient units offer smaller targets for the inefficient ones to reach. So, the firm can make smaller changes in its retention resources. We measure the customer's perspective efficiency based on the worst practice frontier concept. Finally, we use the DEA scores in analysis of customer data that looks for patterns useful for the firm and in churn modelling. This way the efficiency measurement can be part of a marketing management routine.

We apply the concept of FCRE in an online DVD rental firm. The sample consists of customers that have made and paid for repurchases and they have used the service. The issue of zero values in retention investment and cross-buying was brought to the surface, because these were rare. The solution was to split the sample in two depending on RMIs investment being placed or not, while the cross-buying was added to the value of repurchases. Then the DEA models were solved. The results included the level of congesting RMIs investment, the level of congested repurchases and cross-buying, the waste of both firm's resources and potential in sales increase attributed to slacks. We apply the layering technique to show how it creates more feasible steps in improving efficiency. In this particular case, the inefficiency of some customers was found high enough that the usefulness of smaller targets was demonstrated. The customer's perspective efficiency scores are also estimated and these are interpreted through the worst practice frontier concept. The firm can use the worst practice frontier to get the minimum sales targets given the observed resources allocated.

The last goal of this research was to show how the concept of FCRE can be integrated in the firm's marketing management. We focus on customer behaviour. The first step was to discover associations among profit, duration, the efficiency scores and case-specific characteristics. We did

discover that there are opportunities in customer segments that the firm can investigate further. The next step was to try and estimate the effect of the efficiency scores on the probability of churn. In order to do so, the Cox Proportional Hazards model was used to estimate the probability of churn using covariates. The covariates selected had to do with the usage and the membership. In addition to these, the efficiency scores were included separately. Results showed that the effect on the probability of churn of the efficiency scores was positive for both perspectives. The effect of firm's perspective score was positive. The same pattern however was found in the customer's perspective efficiency score. The first can be explained as a customer not being invested as much as another given the purchases can be more likely to churn, but the second is not intuitive. Further investigation needs to be done to investigate the relationship between probability of churn and retention performance.

7.2 Discussion

FCRE helps the firm manage quality as a resource through its effect on retention performance. The suggested models and the application are developed in a way that the firm can incorporate these in its marketing routine. The firm is asked to select which dimensions of quality can vary across customers as well as other resources it invests in them. The firm can also select the customers' responses it is interested in. These can include purchases as well as word-of-mouth communication in social media. This way retention is conceptualized more widely and makes marketing outcomes not financial in nature accountable. It also needs to select customers to assess. It is suggested to select customers it has established a relationship with. This is straightforward for a contractual setting, like memberships. For a non-contractual setting, customers can be selected by how recent their last purchase was.

The results of the models are given down to the customer level. This helps in making suggestions at the customer level and also looking at the bigger picture. The firm then knows the level of its resources that are wasted due to inefficiency. It also knows the level of sales it is losing either because its overinvesting (of RMIs in this case) is having a negative effect on purchases or due to

sales slack meaning these are achievable but not pursued. Apart from the aggregate view, the firm can take action at the customer level to improve performance. Customers found efficient are suggested to receive further investment based on their most productive scale size. The firm is suggested to cut down on the inefficient ones. The reduction can take place in smaller steps using the layering technique. The firm can look for more efficient retention by improving inefficient customers but also increase its effect on the bottom line by increasing productivity. The results from the worst practice frontier complete the efficiency measurement part of the analysis. The firm gets the minimum sales targets for each customer given that the retention allocation strategy will not change. This can be used proactively for low performing retention practices.

The exploratory analysis of customer data with the efficiency scores from best and worst practice frontiers showed no clear relationship with customer profit. This means that customers with few retention resources allocated to them may generate profit, which makes them very attractive to the firm. Although we don't know if this is sustainable, it signals that there is a customer segment worth monitoring closely. The relationship of the efficiency scores with duration through the churn model was found negative. It is intuitive to expect a decrease in retention investment to have a negative impact on retention. The worst customer retention practices have the same impact and that is not expected. A customer who has been treated relatively better should be less prone to leave or even better more prone to stay. We would expect another application to make the relationship between FCRE and churn clearer theoretically. The retention efficiency was developed conceptually and it was applied on a real case with the products of the DEA analysis being put to use for management.

7.3 Limitations

The limitations of this research are found in the resources used, the assumptions on the frontier and the business case. There are other resources on behalf of the customer that can be considered such as the word-of-mouth, engaging in the firm's social presence and effort in co-producing the service or product among others. From the firm's side, the customer would probably appreciate other

outcomes like promptness of customer service and more personal communication. There are also intermediary products like satisfaction and loyalty that lead to increased revenue through retention.

In respect to the methodology, this research is limited to DEA. Typical deterministic frontiers lack the ability to treat statistical noise and are also very sensitive to outliers. The deterministic frontiers constructed are piece-wise linear. A smoother frontier would render different targets. Also, the inputs and outputs are assumed to be contracted and expanded respectively without using any priority. Different firm's goals may impose different weights on the inputs and outputs that in turn would return different targets.

The limitations of the application include the industry that the case study comes from, the type of relationship that was tested and the scarce retention efforts and cross-buying captured. The industry is the online DVD rental. The type of relationship is contractual meaning that the relationship exists because there is a type of contract that is renewed periodically. A non-contractual setting, like the retailer-customer relationship may need a different approach when the actual model is being deployed. Finally, the fact that a small percentage of the relationships involve retention investment and cross-buying has an impact on the assessment of the performance in respect to these resources. When it comes to the post analysis, there are two limitations. One is the analysis on patterns. Other techniques may be used like clustering which is popular in academia and the professional world. Second, the estimation of the probability of churn was done using the Cox PH model that has already been used for this particular metric. It would be useful to see FCRE scores to be included in churn models in different business settings and techniques.

7.4 Future Work

1. **Time**

   FCRE was modelled across aggregate data on the entire lifetime of the firm-customer relationships. The models introduced cannot capture changes in efficiency over time, because they don't take into account changes in the frontier. The use of Malmquist Index in

DEA can help in not only getting the efficiency measured across time but also the overall performance that is productivity. The retention function's performance can be assessed using shorter time-intervals, like monthly, quarterly and so on in terms of efficient and productive operation. The differences in frontiers and in the customers' efficiencies can be analysed further to capture changes in their behaviour. Productivity change over time of retention for each customer can be estimated to see whether this change has an effect on the profit, duration and probability of churn of the customers.

2. **Firm-Customer Relationship**

The firm-customer relationship was built as a concept based on the economic exchange assumption. This relationship is under continuous research in the relationship marketing literature. Further findings may change the type of the resources exchanged and can include apart from the economic part also the emotional one.

3. **Performance measurement**

The concept of the frontier is selected to measure the efficiency. Regression based efficiency models or other developments in deterministic models may prove insightful in further research of FCRE. Also, prioritization of inputs and outputs for target setting will yield different results. Customers may value the firm's resources differently or the firm may value the customers' responses differently. This can be incorporated in the modelling part using weight restrictions. In cooperation with the management team, different performance goals may be set so different approach must be followed. Finally, the goal of the performance measurement may not necessarily be the least inputs used or the maximum outputs produced overall, but may include constraints that have to do with the growth of the relationship, like the probability of churn or satisfaction.

4. **Effect on business**

FCRE was introduced and developed but it is still necessary to monitor how it affects the business. The suggestions from the model and the implementation from management are to be investigated further for their effect on the retention function and at a higher level on business performance. Management will need to take into account FCRE along with the existing set of metrics, like probability of churn, CLV, ROQ among others to make relevant decisions. This will create the opportunity to conduct research on its usability. Findings can suggest further improvement not just for FCRE but for developing productive efficiency models in general in the marketing performance context.

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Appendix

I. Firm-Customer Relationship descriptive statistics

	Profit	Duration	Account Created on Promotion	Total Discs Send
N	1208	1208	1208	1208
Mean	42.69091	279.0994	0.81	36.08
Median	27.405	212.6332	1	23
Std. Error of Mean	1.148756	5.614494	0.011	1.096
Sum	51570.62	337152.1	984	43587
Minimum	-69.14	11.4162	0	2
Maximum	223.78	729.4298	1	303
Range	292.92	718.0136	1	301
Std. Deviation	39.9265	195.139	0.389	38.094
Variance	1594.126	38079.23	0.151	1451.19

Table 20 Descriptive Statistics of Firm-Customer Relationship Account Data

	RMIs	Discs in Top3	Value of Repurchases	Cross Buying Value	Total Value of Retention Purchases
N	1208	1208	1208	1208	1208
Mean	0.190124	21.4031	69.01231	0.8709	69.8832
Median	0	16	47.94	0	47.94
Std. Error of Mean	0.051358	0.53329	1.742723	0.18581	1.76538
Sum	229.67	25855	83366.87	1051.99	84418.86
Minimum	0	1	4.89	0	4.89
Maximum	30	143	399.79	119.8	399.79
Range	30	142	394.9	119.8	394.9
Std. Deviation	1.785006	18.53532	60.5706	6.45801	61.35816
Variance	3.186	343.558	3668.797	41.706	3764.824

Table 21 Descriptive Statistics of Initial Inputs and Outputs

Independent Samples Test										
Total Value of Repurchases – RMIs Investment received or not		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
	Equal variances assumed	11.889	0.001	-3.086	1206	0.002	-41.53411	13.45994	-67.94160	-15.12661
	Equal variances not assumed			-2.049	20.303	0.054	-41.53411	20.27480	-83.78614	0.71793

Table 22 T-test results for Customers who received RMIs investment and those who have not

	RMIs Investment	Discs in Top3	Total Value of Retention Purchases
N	21	21	21
Mean	10.93667	32.8571	110.6952
Median	9	25	74.94
Std. Error of Mean	1.811103	5.63505	20.19868
Sum	229.67	690	2324.6
Minimum	1.67	3	9.99
Maximum	30	85	319.78
Range	28.33	82	309.79
Std. Deviation	8.299518	25.82302	92.56196
Variance	68.882	666.829	8567.716

Table 23 Descriptive statistics of Subset A input-output set

	Discs in Top3	Total Value of Retention Purchases
N	1187	21
Mean	21.2	691,611
Median	15	47.94
Std. Error of Mean	0.532	17,552
Sum	25165	82094.26
Minimum	1	4.89
Maximum	143	399.79
Range	142	394.9
Std. Deviation	18.331	60.47
Variance	336.032	3656.991

Table 24 Descriptive statistics of Subset B input-output set

II. FCRE Scores and Targets

	Firm's Perspective		Customer's Perspective	
	Subset A	Subset B	Subset A	Subset B
N	21	1187	21	1187
Mean	69.38381	13.96206	63.78	22.0239
Median	68.56	9.09	51.76	16.32
Std. Error of Mean	5.976471	0.423539	5.82251	0.5276
Minimum	24.75	1.89	27.78	2.17
Maximum	100	100	100	100
Range	75.25	98.11	72.22	97.83
Std. Deviation	27.38763	14.59214	26.68209	18.1773
Variance	750.0824	212.9306	711.934	330.414

Table 25 Descriptive Statistics for Efficiency Scores

	RMIs Investment Congestion (£)		
DMUs	s_i^{-*} (Total Slack)	δ_i^{-*} (Slack due to Pure Technical Inefficiency)	s_i^{-c} (Slack due to Congestion)
25707	21.74603	0	21.7209
29643	14.23	0	14.2273
24877	11.23	0	11.225
28909	10.67	0	10.67
31591	10.38667	0	10.3523
29247	8.214286	0	8.21429
23542	6.904762	0	6.90476
33348	5.873016	0	5.87302
23023	5.274444	0	5.27444
21856	0.85	0	0.85

Table 26 Estimation of Congestion for RMIs Investment

Whole Customer Base	Quality Delivered	RMIs Investment	Total Value of Repurchases and Cross-Buying	Change on Revenues
Subset A				
Actual	100%	100%	100%	-14.4%
Target	-32%	-51%	+1.4%	
MPSS	-29%	-64%	-13%	
Subset B				
Actual	100%	-	100%	41%
Target	-88%	-	+18%	
MPSS	-88.7%	-	+59%	

Table 27 MPSS against Waste model targets for Subsets A and B aggregated at firm level

III. FCRE and CRM

Correlations

		Profit	Duration	Firm-Efficiency	Customer-Efficiency
Profit	Pearson Correlation	1	0.751**	0.227**	-0.364**
	Sig. (2-tailed)		0	0	0
	N	1187	1187	1187	1187
Duration	Pearson Correlation	0.751**	1	0.004	-0.299**
	Sig. (2-tailed)	0		0.903	0
	N	1187	1187	1187	1187
Firm-Efficiency	Pearson Correlation	0.227**	0.004	1	0.186**
	Sig. (2-tailed)	0	0.903		0
	N	1187	1187	1187	1187
Customer-Efficiency	Pearson Correlation	-0.364**	-0.299**	0.186**	1
	Sig. (2-tailed)	0	0	0	
	N	1187	1187	1187	1187

**. Correlation is significant at the 0.01 level (2-tailed).

Table 28 Correlation Matrix

Independent Samples Test										
Efficiency – Promotion Acquisition		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Firm-Efficiency	Equal variances assumed	36.32	0	3.923	1185	0	4.26562	1.08726	2.13244	6.3988
	Equal variances not assumed			3.111	264.716	0.002	4.26562	1.37127	1.56563	6.96561
Customer-Efficiency	Equal variances assumed	0.321	0.571	-1.581	1185	0.114	-2.15279	1.36173	-4.82446	0.51888
	Equal variances not assumed			-1.598	325.772	0.111	-2.15279	1.34731	-4.80331	0.49773
Profit	Equal variances assumed	72.041	0	21.297	1185	0	53.71313	2.5221	48.76483	58.66142
	Equal variances not assumed			15.746	253.947	0	53.71313	3.41132	46.995	60.43122

Table 29 T-test results of Efficiency Score and Promotion Acquisition Dummy

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Firm-Efficiency	Between Groups	5498.847	6	916.474	4.378	0
	Within Groups	247036.8	1180	209.353		
	Total	252535.6	1186			
Customer-Efficiency	Between Groups	3751.086	6	625.181	1.901	0.078
	Within Groups	388120.3	1180	328.916		
	Total	391871.4	1186			
Profit	Between Groups	160865.9	6	26810.98	18.676	0
	Within Groups	1694028	1180	1435.617		
	Total	1854894	1186			

Table 30 Efficiency Scores and Customer Profit per Membership Level on Account Creation

Variables in the Equation						
	B	SE	Wald	df	Sig.	Exp(B)
CreateLevel			114.57	6	0	
CreateLevel (1)	-1.377	.195	49.982	1	0	0.252
CreateLevel (2)	-1.463	.181	65.204	1	0	0.231
CreateLevel (3)	-.898	.236	14.433	1	0	0.407
CreateLevel (4)	-1.475	.188	61.366	1	0	0.229
CreateLevel (5)	-.446	.155	8.273	1	0.004	0.64
CreateLevel (6)	-.562	.134	17.658	1	0	0.57
PromCreate	.913	.133	47.256	1	0	2.491
IsGift	.737	.181	16.535	1	0	2.089
DVDProblemSolved	-.137	.047	8.522	1	0.004	0.872
Series	-.006	.003	3.706	1	0.054	0.994
MemChange	-.111	.063	3.058	1	0.080	0.895
Efficiency_score_Firm	.010	.002	24.726	1	0	1.010
Efficiency_score_Customer	.023	.002	164.660	1	0	1.023

Table 31 Cox PH Coefficient Results