Mindfully going omni-channel: An economic decision model for evaluating omni-channel strategies

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Abstract: Disruptive digital technologies empower customers to define how they would like to interact with organizations. Consequently, organizations often struggle to implement an appropriate omni-channel strategy (OCS) that both meets customers' interaction preferences and can be operated efficiently. Despite this strong practical need, research on omni-channel management predominantly adopts a descriptive perspective. There is little prescriptive knowledge to support organizations in assessing the business value of OCSs and comparing them accordingly. To address this research gap, we propose an economic decision model that helps select an appropriate OCS, considering online and offline channels, the opening and closing of channels, non-sequential customer journeys, and customers' channel preferences. Drawing from investment theory and value-based management, the decision model recommends implementing the OCS with the highest contribution to an organization's long-term firm value. We validate the decision model using real-world data on the omni-channel environment of a German financial service provider.

Keywords: Channel switching, customer journey analytics, decision model, Markov chain, omni-channel management, value-based management

1 Introduction

Technological innovations such as mobile devices, social media, and online channels fundamentally change customer behavior and omni-channel business (Choudhury & Karahanna, 2008; Mirsch, Lehrer, & Jung, 2016). Today, customers have access to comparison portals, reviews from online communities as well as the possibility of simultaneously seeking information using traditional, online, and mobile channels (Schoenbachler & Gordon, 2002; Rapp, Baker, Bachrach, Ogilvie, & Beitelspacher, 2015). Customers want to decide on their own how to interact with companies during their customer journey (CJ) (Schoenbachler & Gordon, 2002). In particular, new channels and the increasing number of channels affect customers' channel switching and churn behavior (Nunes & Cespedes, 2003). Customers strive to use channels interchangeably and seamlessly during the purchase decision process (PDP) (Verhoef, Kannan, & Inman, 2015). In the banking industry, 20% of customers use digital channels exclusively for information seeking and purchases, whereas 58% use mobile devices for service requests (Accenture Strategy, 2016). Thus, the key challenge of omni-channel management (OCM) is to manage customer behavior across channels by integrating promising or closing obsolete channels (Neslin et al., 2006).

Academic knowledge related to OCM is mature, encompassing both descriptive and prescriptive knowledge. With regard to descriptive knowledge, researchers have intensely analyzed topics such as cross-channel customer behavior, channel adoption, channel choice, and channel usage, as well as their respective effects on organization performance. Based on data from US retailers, Cao and Li (2015) focused on the integration of new channels, finding that new channels positively affect organizations' sales performance. Multichannel shopping is also related to customer profitability, providing insights into how long customers take to adopt a channel (Venkatesan, Kumar, & Ravishanker, 2007). With regard to the influence of new channels, Lui and Piccoli (2016) examined the financial impacts of introducing novel IT-enabled channels into extant multichannel environments. Their work is based on a longitudinal study in the hotel and self-service industries. Similarly, Deleersnyder, Geysens, Gielens, and Dekimpe (2002) investigated whether organizations should add an Internet channel to established channel environments. Using an econometric analysis, they quantified the impact of a new channel on long-term corporate performance in the newspaper industry. Wang, Malthouse, and Krishnamurthi (2015) illustrated the effect of mobile devices on customer behavior. They detected that, in particular, low-spending customers are willing to pay more if they use a mobile channel. Their results also suggest introducing a mobile channel in the search phase rather than promoting new products. Homburg, Vollmayr, and Hahn (2014) investigated whether mere announcements of a broader channel distribution or of new channels influence firm value. In contrast to adding a new online channel, Pauwels, Leeflang, Teerling, and Huizingh (2011) used time series data and an auto-regression model to analyze the impact on revenue of customer acquisition, frequency of orders, returns, and exchanges if organizations open an offline store.

There are significantly fewer prescriptive works on OCM that offer strategies and decision support than there are providing descriptive knowledge. For example, researchers are using attribute models, such as "last-click wins," to study CJs in online environments. Anderl, Becker, Wangenheim, and

Schumann (2014) used this method to obtain information on channel usage and to allocate budgets to channels. Verhoef, Neslin, and Vroomen (2007) analyzed the phenomenon that customers search and purchase using different channels (research shopping), and proposed strategies on how to handle such customer behavior. Balasubramanian, Raghunathan, and Mahajan (2005) focused on customers' channel choices for search and purchase activities, deriving implications for researchers and recommendations for managers. Thomas and Sullivan (2005) also investigated customers' channel choices during their CJs, recommending strategies on how to target and communicate with customers. Hosseini, Oberländer, Röglinger, and Wolf (2015) introduced a decision model for service providers in a multichannel environment, assuming that CJs follow a sequential PDP. Including online and offline channels, as well as customers' channel-switching behavior, their decision model helps evaluate multichannel strategies in terms of their contribution to firm value. Finally, Anderl, Becker, Wangenheim, and Schumann (2016) examined the extent to which digital channels contribute to marketing success, and elaborated on the interaction effects within and across channels, modeling individual CJs as sequential paths using Markov chains. Based on their findings, they derived generalized integrated online marketing strategies.

In sum, the OCM literature predominantly covers online marketing, the distribution of budgets to online channels, and the effects of introducing new channels. Online and offline channels are rarely considered in an integrated manner, a phenomenon that violates the requirements of omni-channel environments (Holland & Flocke, 2014). Moreover, CJs are usually defined to follow sequential and company-defined PDPs, neglecting customer behavior patterns such as non-sequential CJs. This is a drawback, because customers' willingness to comply with company-defined PDPs is decreasing. Most extant descriptive studies consider single facets of OCM in detail, but a holistic perspective is missing. This circumstance holds also true for prescriptive knowledge on OCM. Despite the huge amount of research conducted on OCM, there is a lack of prescriptive knowledge that assists organizations in deriving individual omni-channel strategies (OCS). Therefore, we investigate the following research question: *Which channels should an organization offer in the various steps of the purchase decision process when considering non-sequential customer behavior in an omni-channel environment?*

To address this question, we propose a decision model that enables comparing OCSs in terms of their respective contributions to an organization's long-term firm value. The decision model copes with non-sequential CJs covering pre- and post-sales activities, which are modeled via Markov chains. It also covers omni-channel environments that include online and offline channels. Further, the decision model builds on investment theory and value-based management (VBM) to appropriately model the value contribution of an OCS. When specifying the decision model, we followed the guidelines of normative analytical modeling (Meredith, Raturi, Amoako-Gyampah, & Kaplan, 1989).

The remainder of this paper is organized as follows. In section 2, we outline the relevant theoretical background on OCM and customers' channel choice behavior. In section 3, we introduce our decision model. In section 4, we apply our decision model to a real-world example of a German bank. Lastly, we conclude the paper by summarizing our key results, and describing the limitations of the study and possible avenues for further research.

2 Theoretical Background

2.1 Optimizing Customer Experience via Omni-channel Management

Channels are commonly referred to as an organization's contact media for interacting with customers, consisting of several touchpoints (Neslin et al., 2006; Straker, Wrigley, & Rosemann, 2015). Channels are classified as online (e.g., websites or apps), offline (e.g., agencies or stores), and traditional direct-marketing channels (e.g., catalogs or magazine advertisements) (Verhoef et al., 2015). With the emergence of new technologies, organizations are rethinking how to interact with their customers and how channels can support the steps in the PDP. Based on a content analysis of 100 international companies, Straker et al. (2015) proposed a typology of digital channels, comprising 34 digital touchpoints, to guide channel design decisions. This large number of touchpoints implies that managing and keeping customer interactions consistent across multiple channels is a non-trivial task and, thus, understanding and providing a seamless experience is an essential challenge for customer relationship management (CRM) and multichannel integration (Payne & Frow, 2004).

CRM is an overall strategy with the objective of developing, maintaining, and managing long-term profitable customer relationships (Gneiser, 2010). In the CRM literature, multichannel customers are characterized by not restricting themselves to certain channels when traversing the PDP (Zhang et al., 2010). Empirical results imply that multichannel customers purchase more frequently and spend a larger fraction of their expenses, making them more valuable than single-channel customers (Kushwaha

& Shankar, 2013; Zhang et al., 2010; Cummins, Peltie, & Dixon, 2016). Based on a random sample of one million customers over a four-year period, Kushwaha and Shankar (2013) found that the value contribution of multichannel shoppers exceeds that of “offline only” customers by about 150%, and that of “online only” customers by about 550%. In multichannel management (MCM), an essential component of CRM, channels are typically treated as independent silos and, thus, are optimized separately (Piotrowicz & Cuthbertson, 2014; Nüesch, Alt, & Puschmann, 2015). With each channel following channel-specific goals, organizations seldom exploit their full potential in terms of a seamless customer experience (Pophal, 2015). Extending the ideas of MCM, OCM focuses more intensively on customer behavior. By combining and integrating channels, customers change the way in which they obtain information as well as the way in which they evaluate, make purchase decisions, and interact with organizations, using combinations of channels instead of a single channel throughout the PDP (Nüesch et al., 2015; Lazaris & Vrechopoulos, 2014; Brynjolfsson, Hu, & Rahman, 2013; Trenz, 2015; Payne & Frow, 2004). Thus, OCM blurs the lines between online and offline channels and fosters consistent customer interaction across all channels (Melero, Sese, & Verhoef, 2016; Brynjolfsson et al., 2013). Channels are no longer seen as silos, but intended to offer a unified purchase experience (Nüesch et al., 2015; Nunes & Cespedes, 2003; Van Bruggen, Antia, Jap, Reinartz, & Pallas, 2010).

Every touchpoint and interaction between customers and organizations plays an essential role in optimizing the customer experience (Payne & Frow, 2004). These interactions can be replicated by the process steps of the PDP carried out via specific channels. The PDP typically comprises a pre-sales, a purchase, and an after-sales stage (Choudhury & Karahanna, 2008). Process steps and channels can be conceptualized as a matrix consisting of a PDP and a channel dimension, along which CJs can take place. Against this background, OCM can be regarded as the optimization of the customer experience by considering the channels and the process steps of the PDP (Verhoef et al., 2015).

2.2 Mapping Customers’ Channel-Choice Behavior to Customer Journeys

Associated interactions between customers and organizations via channels are referred to as CJs (Anderl et al., 2014). CJs comprise all activities in the PDP from a customer perspective (Zomerdijk & Voss, 2010). Customers perform CJs according to their individual preferences and specific circumstances in order to accomplish a specific goal, for example, the purchase of a product or the use of a service (Sanz, 2014). Analyzing CJs can provide insights into how past, current, and future customers might use the different channels and touchpoints (Nenonen, Rasila, Junnonen, & Kärnä, 2008).

In the CJ context, the term "hybrid customers" is becoming increasingly popular. Hybrid customers are those who do not fit into a traditional customer segment, as defined by marketing departments (Ehrnrooth & Gronroos, 2013). The interaction with hybrid customers is based on OCM and the fact that they favor using all channel options simultaneously (Rigby, 2011). For instance, customers prefer the personal service from physical stores and the broad product range provided by online stores. Therefore, the number and variety of channels as well as the customers' individual preferences increase the complexity of CJs, leading to non-sequential CJs (Crawford-Browne, 2016). In non-sequential CJs, customers do not traverse the PDP in a company-defined sequential manner, but choose channels and the sequence of PDP steps on their own (Barwitz & Maas, 2016).

Considering complex and individual CJs in combination with the multiple options available to organizations when implementing omni-channel environments, it is crucial to manage customers pursuant to their channel preferences (Zomerdijk & Voss, 2010). Organizations should provide channels that best meet their customers' preferences and that increase the organization's firm value (Zhang et al., 2010). Understanding how shifts in customers' channel-choice behavior occur helps determine the best possible channel options (Payne & Frow, 2004). Customers choose the channel that they expect will provide them with the highest utility relatively to costs (Reardon & McCorkle, 2002). However, customers' channel choice behavior depends on many factors (Barwitz & Maas, 2016). Neslin et al. (2006) identified firm marketing efforts, channel attributes, channel integration, social influence, situational variables, and individual differences as determinants of customers' channel choices. According to Sousa and Voss (2012), the factors influencing channel choice from a customer perspective can be classified into four categories: customer attributes, customer preferences and goals, product and service characteristics, and channel attributes. In addition, the literature highlights customers' perceived financial risk, time loss, and the pleasure of the experience as a hedonic component (Schoenbachler & Gordon, 2002; Cummins et al., 2016; Reardon & McCorkle, 2002; Gupta, Bo-chiuan, & Walter, 2004). Further, past purchase experiences and customers' motivation to buy a product or service via a specific touchpoint, including the price search and evaluation effort, play an important role (Gupta, Bo-chiuan, & Walter, 2004). When considering channels with similar characteristics, customers are likely to have similar switching preferences (Gupta, Lehmann, & Stuart, 2004). Researchers have identified these factors as influencing customers’ perceived value of interaction channels and their switching behavior to other channels.

If organizations consider omitting a specific channel, they must not only consider the customers’ switching behavior to other channels, but also the option that customers might churn. Overall, when determining an appropriate OCS, organizations must understand their customers’ behavior and preferences. Based on the customers’ channel preferences and channel-choice behavior, they should offer different channels in different PDP steps in order to improve their customers’ experience, which, in turn, increases their satisfaction and, consequently, the long-term firm value.

3 Decision Model

3.1 Basic Idea

The decision model aims to identify the OCS with the highest value contribution, in line with the principles of VBM (Martin & Petty, 2000; Ittner & Larcker, 2001). The decision model accounts for different CJs in each possible OCS as well as for the long-term economic impact of each OCS. An OCS covers a specific combination of PDP steps and channels, as established by the organization in focus. CJs can vary if, for instance, a new channel is introduced, an established channel is closed, or particular channels no longer support specific PDP steps. These modifications are the key drivers of identifying the value contribution of alternative OCSs.

As shown in Figure 1, the decision model comprises two components: a CJ analysis component and an investment analysis component. Based on input factors, such as the available channels and involved PDP steps as well as customer information, the decision model first analyzes the CJs of a given OCS. In this way, all possible CJs are represented as a network, an approach allowing us to deal with non-sequential CJs (Tseng, Qinhai, & Su, 1999). We model CJs as an absorbed first-order Markov chain. The absorbing Markov chain property enables us to model specific states in the Markov chain that, once entered, cannot be exited. Such states terminate a CJ (e.g., once a customer has successfully bought a product or exits the PDP). First-order Markov chains assume that the future state of a system depends solely on its current situation (Ferschl, 1970; Sperandio & Coelho, 2006). That is, we assume that customers plan their next step in the PDP intuitively, without being influenced by experiences in previous steps. The decision model then determines the value contribution of an OCS in the investment analysis component by taking a differential investment perspective, based on the CJs, further information about demand evolution, time measurements, and cash flows. That is, we investigate the differences between the original OCS and candidate OCSs to assess their value contribution. Below, we provide details on the general setting and the conversion rate evolution in the CJ analysis as well as on the time and cash flow components of the investment analysis.

Figure 1 - Structure of the decision model for a distinct new channel strategy

3.2 General Setting

In this section, we introduce the main parameters of the decision model, namely, the representation of different OCSs and the conversion rates valid in the current OCS. In addition, in order to model newly emerging conversion rates correctly, we introduce a restriction matrix and a switching matrix.

Our unit of analysis is the OCS of a distinct organization. For the CJ analysis, we model the CJs as a network by mapping two dimensions, as shown in Figure 2 (Barwitz & Maas, 2016). The first dimension represents the channels offered by the organization, while the second dimension represents the available PDP steps. The PDP steps have a logical, sequential order (Anderl et al., 2016). The most prevalent PDP steps are problem recognition, information search, evaluation of product options, purchase decision, and post-purchase support (Gupta, Bo-chiuan, & Walter, 2004). In contrast to this ideal-typical order predetermined by the organization, customers do not necessarily follow this order, but tend to choose the next PDP step on their own, leading to non-sequential CJs (Nüesch et al., 2015). In fact, in an omni-channel environment, customers choose channels, PDP steps, and the (non-sequential) order of PDP steps according to their own channel preferences.

We define the PDP as a sequence of process steps p_j, with $j = 0, \dots, N$ (with $N \geq 1$). A channel c_i, with $i = 0, \dots, M$ (with $M \geq 1$), supports at least one process step. The combination of a PDP step and a channel is called a state. For technical reasons, we supplement the channels offered by the organization with an “Auxiliary channel” to include an “Indefinite” step and a “Termination point” outside the offered channels. We use the "Indefinite" step to model customers outside the organization's PDP to include the possibility that customers can temporarily leave the visible part of the CJ. A customer is outside the CJ if he is no longer visible to the organization or buys from a competitor. We illustrate this phenomenon using a comparison portal. First, a customer starts a CJ by obtaining information about the specific product or service offering. Then, the customer might leave the PDP temporarily to compare this information with that on other portals before continuing and buying the product. The "Termination point" covers the Markov chain property of absorption as a terminal point with no outgoing edges, where the customer concludes the process by either completing or canceling the transaction. The process steps "Indefinite" and "Termination point" appear only in the "Auxiliary channel."

A specific OCS X, as shown in Eq. (1), describes which channels support particular process steps. The binary variable $x_{i,j}$ refers to a state, and specifies whether channel c_i supports step p_j:

$$X = \begin{pmatrix} x_{0,0} & \cdots & x_{0,N} \\ \vdots & \ddots & \vdots \\ x_{M,0} & \cdots & x_{M,N} \end{pmatrix} \qquad x_{i,j} = \begin{cases} 1 & \text{if channel } c_i \text{ supports process step } p_j \\ 0 & \text{else} \end{cases} \tag{1}$$

The variable $x_{0,0}$ represents the "Indefinite" state, while $x_{0,N}$ represents the "Termination point." The states $x_{1,0}, \dots, x_{M,0}$ and $x_{0,1}, \dots, x_{0,N-1}$ and $x_{1,N}, \dots, x_{M,N}$ are, by definition, equal to 0, because they are technical model-specific components, as shown in Fig. 2. Eq. (2) expresses the customers' preferences to stay within the same channel or to switch channels along the PDP in terms of a quadratic conversion matrix R. This matrix covers all conversion rates of the organization's current OCS. Each conversion rate $r_{i,j,k,l}$ depicts the fraction of customers in channel c_i and step p_j (state $x_{i,j}$) who continue their CJ using channel c_k to proceed to step p_l (state $x_{k,l}$).

$$R = \begin{pmatrix} r_{0,0,0,0} & \cdots & r_{0,0,M,N} \\ \vdots & \ddots & \vdots \\ r_{M,N,0,0} & \cdots & r_{M,N,M,N} \end{pmatrix} \text{with } r_{i,j,k,l} \in [0;1] \; \forall i,k \in \{0,\dots,M\} \wedge j,l \in \{0,\dots,N\} \tag{2}$$

Figure 2 illustrates the idea of non-sequential CJs, channels, and PDP steps, including the "Auxiliary channel" for the technically required process steps "Indefinite" and the "Termination point."

Figure 2 - Representation of channels, process steps, and non-sequential CJs in the PDP

As mentioned above, customers arrange their CJs according to their own preferences. However, PDPs may be subject to restrictions, for logical or legal reasons. For instance, a logical restriction would be that a customer cannot have a meeting without first scheduling it beforehand. A legal reason could be that customers must have an obligatory consultation before signing the contract of a complex banking product. To integrate such restrictions, we introduce a restriction matrix Q, as in shown in Eq. (3), which determines whether it is possible to go from the current process step to the next process steps.

$$Q = \begin{pmatrix} q_{0,0} & \cdots & q_{0,N} \\ \vdots & \ddots & \vdots \\ q_{N,0} & \cdots & q_{N,N} \end{pmatrix}, \tag{3}$$

$$\text{with } q_{i,j} = \begin{cases} 1 & \text{if the conversion from step } p_i \text{ to } p_j \text{ is allowed} \\ 0 & \text{else} \end{cases} \quad \forall j, l \in \{0, \dots, N\}$$

Because the "Termination point" describes the final state of a CJ, and there is no possibility of leaving this state, the variables $q_{N,0}$, …,$q_{N,N}$ are zero, by definition. An organization can decide to change its OCS by opening or closing channels completely or within specific PDP steps. In the case of closing a channel for a specific PDP step, customers might not be able to traverse the PDP as they wish. Hence, they will need to choose other channels or PDP steps to proceed, or decide to leave the CJ (Sonderegger-Wakolbinger & Stummer, 2015; Reardon & McCorkle, 2002). For instance, in the banking industry, organizations tend to close branch offices for financial reasons, which means customers have to shift to online banking. This phenomenon is called enforced channel switching, which impacts other conversion rates, leading to modified conversion rates. Channel switching determines how customers spread to other channels and/or PDP steps. The channel switching rate $s_{i,k}$ denotes the rate at which customers are reallocated from channel c_i to channel c_k if one of the channels is closed or opened. Eq. (4) shows all switching rates in the matrix S:

$$S = \begin{pmatrix} s_{0,0} & \cdots & s_{0,M} \\ \vdots & \ddots & \vdots \\ s_{M,0} & \cdots & s_{M,M} \end{pmatrix} \text{with } s_{i,k} \in [0;1] \; \forall i, k \in \{0, \dots, M\} \tag{4}$$

3.3 Customer Journey Analysis

We now outline how the decision model uses the input information from the general setting to perform the CJ analysis and to calculate the modified conversion rates of a specific OCS. Adding and removing or, respectively, enabling or disabling states affects existing conversion rates, because customers now have different options to navigate through the PDP. We refer to the modified conversion rates as $r_{i,j,k,l}^{\mathrm{mod}}$, representing the conversion of customers between state $x_{i,j}$ and state $x_{k,l}$ in a new OCS.

Figure 3 - Possibilities to change an OCS

Figure 3 and Eq. (5) explain how CJs are affected when an organization modifies its OCS. The first summand refers to customers changing their CJ because a channel no longer supports a PDP step. As a consequence, customers use other paths, or may leave the CJ. The second summand describes the negative influence on existing conversion rates if a channel begins to support a new PDP step and, thus, customers use this new option instead of established paths. The third summand considers the same effect, but from the perspective of the newly established state, which gains customers. Once a new channel is established in the OCM, it is also important to know which states customers subsequently use. Accordingly, the fourth summand describes the new paths customers use after the new state in the new OCS.

$$
\begin{aligned}
r_{i,j,k,l}^{\mathrm{mod}} = \quad & x_{i,j} \cdot x_{k,l} \cdot q_{j,l} \cdot \Big\{ r_{i,j,k,l} \\
& + \sum_{t=0}^{M} \sum_{u=0}^{N} F_1 \cdot r_{i,j,t,u} \cdot (1 - x_{t,u}) \\
& - \sum_{t=0}^{M} \sum_{u=0}^{N} F_2 \cdot r_{i,j,k,l} \cdot y_{t,u} \\
& + \sum_{t=0}^{M} \sum_{u=0}^{N} F_3 \cdot r_{i,j,t,u} \cdot y_{k,l} \\
& + F_4 \cdot y_{i,j} \Big\}
\end{aligned}
\tag{5}
$$

where:

$r_{i,j,k,l}$	Original conversion rate from state $x_{i,j}$ to state $x_{k,l}$
$r_{i,j,k,l}^{\mathrm{mod}}$	Modified conversion rate from state $x_{i,j}$ to state $x_{k,l}$
$x_{i,j}$	Indicator showing whether state $x_{i,j}$ is open or closed in the new OCS
$y_{i,j}$	Indicator showing whether state $x_{i,j}$ is a new state
$q_{j,l}$	Indicator showing whether a conversion from PDP steps p_j to p_l is possible (component of the restriction matrix)
M	Number of channels
N	Number of PDP steps, including the “Termination point”

F_1	Fraction consisting of switching rate from a closed channel and switching rates to all other relevant states
F_2	Fraction consisting of switching rate to a specific new state and switching rates to all other relevant states (from the perspective of an existing state)
F_3	Fraction consisting of switching rate to a specific new state and switching rates to all other relevant states (from the perspective of a new state)
F_4	Fraction consisting of switching rate from a state in a new channel and switching rates to all other relevant states

Below, we elaborate on the meaning of Eq. (5). The conversion rate $r_{i,j,k,l}$ is only reasonable if states $x_{i,j}$ and $x_{k,l}$ are open and not restricted by the restriction matrix Q. Multiplying the respective three binary variables captures this circumstance by assigning the value 0 to the conversion rate if the three conditions are not met. In the case of a possible conversion rate, Eq. (5) adds and subtracts the changes of the conversion rate based on the original conversion rate $r_{i,j,k,l}$, which we explain in the following.

The first summand accounts for enforced channel switching, and adds the rate of those customers who, in the new OCS, convert to state $x_{k,l}$ when some outgoing edges of state $x_{i,j}$ are no longer possible because the organization has closed the related states. For example, an organization might decide to cancel its catalog offerings, which means customers must choose from alternative states. The multiplier $r_{i,j,t,u} \cdot (1 - x_{t,u})$ checks all states, and is greater than 0 if state $x_{t,u}$ is a closed state, and if there was originally some conversion from state $x_{i,j}$ to closed state $x_{t,u}$. We define the fraction F_1, displayed in Eq. (6), as the ratio of the switching rate $s_{t,k}$ to the switching rates from state $x_{t,u}$ to all opened states that have a conversion from state $x_{i,j}$. Overall, F_1 determines the rate of customers switching to another state. For this fraction, and for all following divisions, it is reasonable to define that if the denominator of a division is equal to 0, the result of the division is equal to 0.

$$F_1 = \begin{cases} \dfrac{s_{t,k}}{\sum_{a=1}^{M} \sum_{b=1}^{j} s_{t,a} \cdot x_{a,b} \cdot \mathrm{sgn}\left(r_{i,j,a,b}\right) + s_{t,0} \cdot \mathrm{sgn}\left(r_{i,j,0,0}\right)} & \text{if } u - j < 0 \wedge l - j < 0 \\ \dfrac{s_{t,k}}{\sum_{a=1}^{M} \sum_{\substack{b=j \\ b \neq 0}}^{N} s_{t,a} \cdot x_{a,b} \cdot \mathrm{sgn}\left(r_{i,j,a,b}\right) + s_{t,0} \cdot \mathrm{sgn}\left(r_{i,j,0,0}\right)} & \text{if } u - j > 0 \wedge l - j > 0 \\ 0 & \text{else} \end{cases} \tag{6}$$

Customers who wanted to move forward in the PDP will keep their attitude of moving forward, and customers who wanted to move backward in the PDP will keep their attitude of moving backward. Thus, we divide the fraction F_1 in two cases to calculate the ratio of the switching rates to only those states that lie in the same direction along the PDP as that of the closed state. If customers are close to buying a product and a changes in the OCS occurs, the customer would most likely not restart the CJ by gathering information about the product (Melero et al., 2016). Because the “Indefinite” state is not integrated in the process sequence, the switch to the “Indefinite” state is included in both cases.

The second summand subtracts the rate of customers who choose the conversion to newly enabled states. For instance, if an organization introduces a new mobile app, some customers may refrain from using existing channels, and rather use the new mobile app. The variable $y_{t,u}$ verifies all states, and is equal to 1 if state $x_{t,u}$ is a new state, and 0 in all other cases, as shown in Eq. (7).

$$y_{i,j} = 1 + \operatorname{sgn}\left(x_{i,j} - x_{i,j}^{\text{old}} - 1\right) = \begin{cases} 1 & \text{if } x_{i,j} \text{ is a new state} \\ 0 & \text{else} \end{cases} \tag{7}$$

The fraction F_2 is the ratio of switching rate $s_{k,t}$ to the switching rates between state $x_{t,u}$ and all open states with a conversion from state $x_{i,j}$ (see Eq. (8) and Eq. (9)):

$$F_2 = \frac{s_{k,t}}{count_j \cdot \sum_{a=0}^{M} \sum_{b=0}^{N} s_{a,t} \cdot x_{a,b} \cdot \operatorname{sgn}\left(r_{i,j,a,b}\right)} \tag{8}$$

$$count_j = \sum_{a=0}^{M} \sum_{b=0}^{N} y_{a,b} \cdot q_{j,b} \tag{9}$$

Thereby, the variable $count_j$ counts the number of new states that customers can possibly move to, starting from PDP step p_j. This factor ensures an appropriate allocation to all new states. Because new options, such as new states, can change the attitude of customers in terms of moving forward or backward, we do not divide the fraction F_2 into different cases, as we did for F_1.

The third summand defines the conversion to state $x_{k,l}$ if $x_{k,l}$ represents a new state. This means it creates the ingoing edges into a new state. For example, an organization might introduce the option of buying products via mobile app, which customers may begin to use. The variable $y_{k,l}$ again checks all states. Fraction F_3 is the ratio of switching rate $s_{t,k}$ to the switching rates between states $x_{k,l}$ and all open states that have a conversion from $x_{i,j}$, including the number of new states to which the customer can move from process step p_j, as shown in Eq. (10).

$$F_3 = \frac{s_{t,k}}{count_j \cdot \sum_{a=0}^{M} \sum_{b=0}^{N} s_{a,k} \cdot x_{a,b} \cdot \operatorname{sgn}\left(r_{i,j,a,b}\right)} \tag{10}$$

Finally, the fourth summand calculates the outgoing edges of $x_{i,j}$ if $x_{i,j}$ is a new state. For instance, if customers use a new mobile app, they have to decide which channel they want to use in order to proceed to the next PDP step. This case occurs if the variable $y_{i,j}$ signals that state $x_{i,j}$ is a new state. Here, F_4 is the ratio of the switching rate $s_{i,k}$ to the switching rates between state $x_{i,j}$ and all other open states, as shown in Eq. (11).

$$F_4 = \frac{s_{i,k}}{\sum_{a=0}^{M} \sum_{b=0}^{N} s_{i,a} \cdot x_{a,b}} \tag{11}$$

Thus, we calculate $r_{i,j,k,l}^{\text{mod}}$, which consists of the original conversion rate $r_{i,j,k,l}$ and all possible changes that can occur when states are opened or closed for any possible candidate OCS. After compiling the modified conversion rate $r_{i,j,k,l}^{\text{mod}}$ for all states in the CJs, the conversion rates are normalized such that the outgoing conversion rates from each state sum to 1, as shown in Eq. (12). The modified and normalized conversion rates $r_{i,j,k,l}^{\text{res}}$ are the result of all previous calculations, and build the final modified conversion rate matrix R^{res} after changing the original OCS:

$$r_{i,j,k,l}^{\text{res}} = \frac{r_{i,j,k,l}^{\text{mod}}}{\sum_{a=0}^{M} \sum_{b=0}^{N} r_{i,j,a,b}^{\text{mod}}} \forall i \in \{0, \dots, N\}; j \in \{0, \dots, M\} \tag{12}$$

3.4 Investment Analysis

In this section, we show how the decision model determines the monetary value contribution of a specific candidate OCS, using the modified and normalized conversion rate matrix as well as additional information on demand, time measurements, and cash flows. The organization can decide between multiple OCSs. In order to compare OCSs, we take a differential investment perspective. That is, the decision model measures the value contribution of a specific OCS by comparing its effects to those of the current OCS. In line with the principles of VBM, the decision model recommends choosing the OCS that results in the highest positive value contribution. The principles of VBM imply that decisions take a long-term perspective, are based on cash flows, and account for decision-makers' risk attitudes (Buhl, Röglinger, Stöckl, & Braunwarth, 2011).

In the investment analysis, the decision model considers specific cash inflows and outflows. We assume these cash flows to be constant and deterministic throughout the planning horizon. On the one hand, there are recurring cash flows for the operational maintenance of the organization's OCM. On the other hand, there are also non-recurring investment cash flows, for example, for implementing a new channel or for supporting a new PDP step. We define every cash flow as a positive vector. In all, we distinguish four different components: variable, operational, investment, and configuration cash flows. The recurring operational cash flows I^{op} consist of variable outflows μ^{var}, such as the costs of verifying a credit application, and variable inflows π, such as the prices of products or services purchased by each customer. Operational outflows μ^{op}, such as the labor cost for an offline channel or IT maintenance costs for an online channel, accrue in each period τ.

In the following, we elaborate on the time parameters shown in Fig. 4. The planning horizon T determines how many periods τ have been chosen to investigate candidate OCSs. The length of a period is characterized by the variable θ, which can be measured in, for instance, days or months. A period characterizes a planning period for the operational costs I^{op} as well as the time basis for estimating the number of customers traversing the PDP. Further, the variable η describes the length of a PDP step, quantified in the same measurement unit as θ. Thus, every PDP step has a duration of θ. Nevertheless, customers can take more time for specific PDP steps, a circumstance represented by loops within the network. For example, some customers require more time to decide on a product or may favor a second appointment in case the first negotiation appointment is not sufficient. Such behavior can be modeled as loops in the Markov chain, representing a self-directed conversion from a state to itself. The last parameter for measuring time is the number of PDP steps H, which is the maximum number of process steps considered for a PDP. Thus, the product of H and θ measures the length of a PDP, and $\theta/(H \cdot \eta)$ measures the number of PDPs in one period τ. Fig. 4 shows the relationship between the time elements. This model allows us to take different recurring operational costs I^{op} into account properly, while specific PDPs are independent of the duration of one period. Thus, the long-term perspective and the time value of money are incorporated, in line with the VBM principles.

Figure 4 - Relationship between time parameter

Furthermore, the decision model allows us to consider changes in the number of customers in terms of growth rates or seasonal effects. The customer demand vector $D_{0,\tau}$ depicts the average number of customers for every possible state as the starting point of their CJ at the beginning of a period τ. In other words, the customer demand vector indicates how many and where customers start their CJ. The demand vector is constant and deterministic for one period, but the decision model allows for adjusting the number of customers in different periods, as shown in Eq. (13) Then, Eq. (14) represents the recurring operational cash flows I^{op}.

$$D_{0,\tau+1} = D_{0,\tau} \cdot (1 + NewCustomerRate_\tau - ChurnRate_\tau) \tag{13}$$

$$I^{\text{op}} = \sum_{\tau=1}^{T} \left(\frac{\frac{\theta}{H \cdot \eta} \sum_{h=1}^{H} \left[\left(D_{o,\tau}^{\text{mod}} \cdot (R^{\text{res}})^h - D_{o,\tau} \cdot R^h \right) \cdot (\pi - \mu^{\text{var}}) \right]}{(1+r)^\tau} \right) - \mu^{\text{op}} \cdot \begin{pmatrix} Z_0 \\ \vdots \\ Z_N \end{pmatrix} \cdot \frac{(1+r)^T - 1}{(1+r)^T \cdot r} \tag{14}$$

where:

R	Conversion rates of original OCS
R^{res}	Conversion rates of new OCS
π	Variable inflows per state
μ^{var}	Variable outflows per state
μ^{op}	Operational outflows per channel
$D_{0,\tau}$	Demand vector in original OCS in period τ
$D_{0,\tau}^{\text{mod}}$	Demand vector in new OCS in period τ
T	Number of periods τ
H	Maximum number of steps for CJ
θ	Length of a period
η	Length of one process step
r	Interest rate
Z_i	Indicator showing whether channel i is new or closed ($i \in \{0, \dots, N\}$).

The first term of Eq. (14) calculates the variable cash flows for one period τ. The multiplication of the customer demand vector $D_{o,\tau}^{\text{mod}}$ by $(R^{\text{res}})^h$ determines the new status of the customers in the network after h process steps, based on the properties of the Markov chain. Thus, the decision model calculates different CJs and their respective variable cash flows. This expression is then summed for each process step in the CJs and multiplied by the number of PDPs to calculate the cash flows of one period τ.

The second term of Eq. (14) reflects the operational outflows accruing for the offered channels. Thus, we add the operational outflows in our differential investment perspective when a channel is opened, and subtract the operation outflows when a channel is closed. The variable Z_i, shown in Eq. (15), refers to this phenomenon. Here, Z_i is equal to 1 if channel c_i is new, –1 if channel c_i (with all corresponding process steps) is closed, and 0 in all other cases.

$$Z_i = \operatorname{sgn}\left(\sum_{n=0}^{N} x_{i,n}\right) - \operatorname{sgn}\left(\sum_{n=0}^{N} x_{i,n}^{\text{old}}\right) = \begin{cases} 1 & \text{if } c_i \text{ is a new channel} \\ 0 & \text{else} \end{cases} \tag{15}$$

In addition to the recurring operational cash flows, we need to consider the non-recurring investment cash flows I^{inv}. The investment cash flows depend on the changes in the OCM from either building up or closing a complete channel compared with the original OCS. To calculate the investment and disinvestment of a channel, we sum the channel investment outflows for all opened channels and the channel disinvestment cash flows for all closed channels, as shown in Eq. (16).

$$I^{\text{inv}} = -\sum_{i=0}^{M} \mu_i^{\text{inv,open}} \cdot [\operatorname{sgn}(Z_i - 1) + 1] - \sum_{i=0}^{M} \mu_i^{\text{inv,close}} \cdot [1 - \operatorname{sgn}(Z_i + 1)] \tag{16}$$

where:

$\mu_i^{\text{inv,open}}$	Investment outflows for building up channel i
$\mu_i^{\text{inv,close}}$	Disinvestment cash flows for closing channel i completely
Z_i	Indicator if channel i is new or closed

If a new channel supports a PDP step, or if a channel is closed for a PDP step, then the structure within the channel changes and, thus, the organization must invest or disinvest non-recurring configuration cash flows I^{conf} for the new or cancelled possibilities. Eq. (17) shows how the configuration cash flows are calculated:

$$\begin{aligned} I^{\text{conf}} = \quad & -\sum_{i=0}^{M} \mu_i^{\text{conf,open}} \left(\sum_{j=0}^{N} y_{i,j} \cdot \operatorname{sgn}\left(\sum_{n=0}^{N} x_{i,n}^{\text{old}}\right)\right) \\ & -\sum_{i=0}^{M} \mu_i^{\text{conf,close}} \left(\sum_{j=0}^{N} z_{i,j} \cdot \operatorname{sgn}\left(\sum_{n=0}^{N} x_{i,n}^{\text{old}} - \sum_{n=0}^{N} z_{i,n}\right)\right) \end{aligned} \tag{17}$$

where:

$\mu_i^{\text{conf,open}}$	Configuration investment costs if channel i supports a new process step
$\mu_i^{\text{conf,close}}$	Configuration disinvestment costs if channel i no longer supports an established process
$x_{i,j}^{\text{old}}$	Indicator showing whether state $x_{i,j}$ is open or closed in the original OCS
$y_{i,j}$	Indicator showing whether state $x_{i,j}$ is a new state
$z_{i,j}$	Indicator showing whether state $x_{i,j}$ is new or closed

The computation of the configuration costs for single PDP steps follows the same logic as the calculation of I^{inv}. Conversely, $z_{i,j}$ is an indicator variable equal to 1 if state $x_{i,j}$ is closed, and 0 in all other cases, as shown in Eq. (18). Based on the introduced cash flow components, Eq. (19) allows for identifying OCS X, which has the highest value contribution, including recurring operational, non-recurring investment, and configuration cash flows, based on the CJ analytics.

$$z_{i,j} = -\text{sgn}\left(x_{i,j} - x_{i,j}^{\text{old}} + 1\right) - 1 = \begin{cases} 1 & \text{if } x_{i,j} \text{ is a closed state} \\ 0 & \text{else} \end{cases} \quad (18)$$

$$\max_X \; I^{\text{op}} + I^{\text{inv}} + I^{\text{conf}}. \quad (19)$$

4 Real-world Case Study

4.1 Case Description

To demonstrate the applicability of our decision model in a real-world scenario, we applied it to the omni-channel environment of a German financial service provider (FSP). We focus on the FSP's construction financing offering, which includes construction insurances and loan hedging. The FSP is a German cooperative bank with a tradition of more than 200 years. It has approximately 600 employees within 40 branches, and current total assets of more than 2 million EUR. Construction financing is a service offering for financing building construction. In general, the bank offers a broad spectrum of channels in order to reach as many customers as possible. Therefore, we refrain from changing or closing channels within the extant omni-channel environment. Here, we first outline the case context and provide information on the bank's current OCS. Then, we explain how we collected and prepared the data. Next, we report the results of applying the decision model, before concluding by analyzing and interpreting the optimization results.

The bank's PDP of the construction financing offering has the following steps: "Need/Interest," "First contact," "Schedule of appointment," "Information," "Consulting," "Negotiation," and "Conclusion of contract." Not all steps are mandatory in all CJs. Customers may skip the steps "Need/Interest" and "First contact" as they may occur in any form. They do not necessarily happen in the considered channels, but rather via word of mouth. Consequently, they are difficult to observe. The PDP step "First contact" is not mandatory either, because customers may be regular customers. However, for prospects, the process step "First contact" is mandatory. The steps "Schedule of appointment," "Information," and "Negotiation" are mandatory in the CJs of all customers, but some customers may repeat these steps by rescheduling appointments, reconsidering the provided information, or requiring several appointments to negotiate contract conditions. The PDP ends with a contract or with customers leaving the PDP.

Regarding interactions between customers and the bank along the PDP, the bank currently implements an OCS with three channels: an "Agency" channel; an "Online" channel, via a website and a mobile app, which the bank considers as a single integrated channel; and a "Brochures" channel for marketing activities. In future, with a planning horizon of three years, the bank is planning to extend its OCS with an additional "Online for standards" channel, which will automatically process standardized contracts and sections of contracts. In addition, the channels "Telephone" and "Video" shall provide customers with new ways of contacting bank employees. The bank's current setting, without the newly considered channels, is the starting position for the application of our decision model. Fig. 5 illustrates the bank's current omni-channel environment. Currently, only the "Agency" channel supports the PDP steps "Consulting," "Negotiation," and "Conclusion of contract." The planned new channels feature different properties, depending on whether customers personally conclude contracts with an agency, whether the contact is automated, or whether the contact is one- or bi-directional. For example, the "Agency," "Telephone," and "Video" channels support bi-directional personal contact among employees and customers, while the response to customers using the two online channels is automated. The "Brochures" channel offers a one-directional channel, providing customers with relevant information. Owing to these channel properties, not all channels can support all PDP steps.

Figure 5 also shows all theoretically possible CJs, depending on the channel properties and mandatory PDP steps, capturing the complexity of a real-world omni-channel environment. In this example, it is important to model non-sequential CJs in order to better capture the customers' behavior. The more PDP steps there are that are non-obligatory and the more possibilities that exist in choosing channels, the more complex the CJs are.

Figure 5 - Current omni-channel environment at the case company

4.2 Data Collection and Preparation

To apply the decision model to the bank's omni-channel environment, we first presented our idea to the head of global bank management, the head of the sales department, and the department head for private and commercial customers. We then collected and validated the required data using an iterative process. Our primary contact person was a member of the bank's sales department, who consulted specific other departments if needed. Then, we used the collected data as input to our model. Wherever necessary, we used additional information from the literature or insights from interviews with other industry and academic experts to prepare the collected data or to validate our estimations. Below, we provide information on the data sources and where we complemented these with external data.

The bank's omni-channel environment and possible CJs were easily identified as channels and PDP steps constituted the bank employees' daily work. Thus, much of the data could be retrieved directly from the sales department. Further, the bank's controlling department provided us with detailed information on monetary data, particularly concerning variable costs, sales prices, investments, and operational costs. The configuration costs capture the costs of opening or closing a single PDP step in an established channel. Thus, they supplement investments in opening a channel, accounting for the specific number of supported PDP steps. Because it is difficult to assign costs to specific PDP steps, most organizations (including our case company) do not have sufficient data on the configuration costs for each channel. Thus, we discussed these costs with the bank's employees, and estimated the configuration costs to be equally high for each channel and PDP step. Relevant data on time (i.e., the planning horizon, length of a period, length of PDP steps), demand, and how often the PDP steps for construction financing are executed were provided by the bank's sales management department.

The conversion rates were known in some cases (e.g., the number of customers leaving the PDP). However, we were able to estimate the remaining unknown conversion rates based on the existing rates and on the fraction of customers using each channel. The most difficult data to collect were the switching rates. Because modeling customer behavior in terms of Markov chains and channel switching rates is a novel approach proposed in this study, organizations usually do not have such data. To estimate the switching rates, we used the fact that the decision model does not require the absolute values of the switching matrix, but only relative ratios. Therefore, we simplified the required input data in agreement with our contact persons at the bank, distinguishing between the categories "low," "medium," "high," and "very high" for switching preferences, with values of 0.25, 0.5, 0.75, and 1, respectively. Because similar channels lead to low (cognitive) opportunity costs for customers and, thus, facilitate switching, we based our classification on channel similarity and the customer behavior trends identified by the bank (Gupta, Lehmann, & Stuart, 2004). Table 1 summarizes the collected input data. We display the conversion rates in the Appendix, owing to the high number of relevant conversion rates.

Table 1 - Real-world input data for the demonstration example

4.3 Optimization Results

In line with the bank's corporate objectives, we aimed to identify the OCS with the highest value contribution (i.e., the highest contribution to the bank's long-term firm value). The best OCS yields a value contribution of 877,212 EUR. To achieve this value, the bank is advised to integrate the "Online for standards" channel completely, except for the step "Negotiation," which is not needed for standard products, as indicated in expert interviews. The bank should also add the "Telephone" channel only for the steps "Information" and "Conclusion of contract."

The problem of determining an optimal OCS is quite complex, requiring a full enumeration of all possible OCSs. In this case, there are 16,384 possible OCSs. Thus, we only present the partial results here, namely the most interesting and remarkable OCS, from our perspective. Table 2 shows the bank's current OCS, the stepwise integration of a new channel to determine a channel-specific local optimum, and all combinations of introducing one, two, or all discussed channels. We further highlight the OCS that the bank would have liked to implement prior to gaining the insights from applying our decision model. We also compare this OCS with the optimal OCS determined by our decision model.

Table 2 - OCSs and corresponding value contributions

4.4 Interpretation and Discussion

Here, we interpret and discuss the optimization results. As mentioned, the bank aims to offer a broad spectrum of channels in order to reach as much customers as possible. Therefore, we deliberately refrain from changing or closing channels from the extant omni-channel environment. Hence, we focus on integrating the three new channels the bank is currently considering. The OCSs presented in Table 2 show that the decision model can be applied in practice. The required input parameters can be collected or estimated with reasonable effort. In the following, we discuss the various OCSs and their consequences. For OCS 1, keeping the bank's current OCS results in no value contribution, which complies with the differential investment perspective underlying our decision model. Further, OCSs 2 to 7 capture the stepwise integration of the "Online for standards" channel along the PDP. Owing to the customer behavior in terms of non-sequential CJs, the integration of this channel only yields a positive value contribution if it supports all PDP steps. From OCSs 8 and 9, using the "Telephone" channel as an example, we can infer that there are channel-specific local optima. For instance, in the "Telephone" channel, it is more reasonable to support the last process steps "Negotiation" (step 6) and "Conclusion of contract" (step 7) than it is to support all process steps. Up to OCS 14, we list all combinations of the three potentially new channels. For every channel, OCSs 7, 9, and 10 reflect the respective local optima. Note that the combination of locally optimized channel strategies does not lead to a globally optimal OCS in terms of value contribution. This phenomenon is again rooted in the non-sequential CJs (Katz & Shapiro, 1994).

The bank initially aimed to implement an OCS that includes all three newly discussed channels. This OCS is represented as OCS 15 in Table 2, and has a rather low, but positive value contribution. Thus far, the complete introduction of the channel "Online for standards" (OCS 7) has the highest value contribution (i.e., 796,693 EUR). The process step "Negotiation" (step 6) causes considerable variable costs because we modeled a loop for this step, representing the fact that most customers need more time for this step than actually planned. The effect on the bank's omni-channel environment is that it avoids the PDP step "Negotiation" (step 6), if possible. OCS 16 accounts for this circumstance, indicating that the optimal OCS includes a combination of the "Online for standards" and "Telephone" channels. This

OCS leads to a value contribution of 877,212 EUR, a value more than three times higher than the bank's initially preferred OCS (OCS 15).

In the case at hand, we detected that it is not useful to ignore or to integrate all new channels in the bank's omni-channel environment. The appropriate choice of new channels depends on the channel properties and on the customers' behavior in terms of non-sequential CJs. In particular, the "Telephone" and "Video" channels are very similar in terms of their characteristics and their inflows and outflows, compared with the established channels. Consequently, it is not reasonable to implement both channels because customers perceive the two as strongly substitutable. According to the collected input data, the "Telephone" channel causes lower cash outflows, but similar cash inflows to the "Video" channel. Thus, this channel should be preferred. In addition, the investigated OCS tends to yield a higher value contribution if the integrated channels support every step of the bank's PDP. Finally, our analysis reveals that time-intensive PDP steps of non-standardized products, such as "Negotiation," are realized by the "Agency" channel, even if the bank introduces new channels. Thus, customers prefer direct and personalized contact with agencies on matters concerning construction financing.

Finally, Fig. 6 shows the bank's omni-channel environment, including the anticipated CJs, after implementing the optimal OCS. Customers now have more possibilities in terms of interacting with the bank. Further, the structure of the non-sequential CJs is even more complex. The "Agency" channel is also relieved by additional channels for the first four process steps and the "Conclusion of contract" step. This effect is evident in the matrix representation of all conversion rates.

Figure 6 - Omni-channel environment at the case company after implementing the optimal OCS 16

5. Conclusion

5.1 Summary and Contribution

Accounting for the increasing importance of OCM and the lack of prescriptive knowledge, we investigated which channels organizations should offer in various steps of the PDP when considering non-sequential customer behavior in an omni-channel environment. As such, we proposed an economic decision model that compares individual OCSs in terms of their contribution to an organization's long-term value. For the purposes of our study, we modeled OCSs as combinations of channels and PDP steps, while capturing CJs via Markov chains. This design enabled us to include online and offline channels, the opening of new channels and closing of existing channels, customer churning as a result of enforced channel switching, and non-sequential customer behavior in omni-channel environments. With non-sequential customer behavior becoming increasingly important in the digital economy, it is particularly important for decision-making in omni-channel environments. Providing guidance on how to optimize an organization's individual OCS, our decision model adds to the prescriptive knowledge on OCM and to that on CJ analytics. We validated the decision model's applicability using a case study based on real-world data of a German bank, finding that the required input data can be collected or estimated with reasonable effort by subject matter experts. However, there are also limitations to the model and ways in which the model can be improved. Below, we present these limitations, divided into model-specific and application-specific limitations, accompanied by ideas for further research.

5.2 Limitations and Future Research

As in any mathematical modeling project, our decision model is subject to limitations. First, we assume that the input parameters of our model are constant and deterministic in the planning horizon. However, in reality, cash flows and customer behavior are uncertain. We deliberately constrained our model to keep the complexity and amount of input data manageable. Nevertheless, we explicitly account for the monetary effects of individual OCSs in different periods of the planning horizon. In future research, these deterministic effects may be replaced by random variables with individual probability distributions. This substitution would result in a stochastic decision model, which would account for economic effects more precisely. Second, we modeled CJs using first-order Markov chains, assuming that future customer behavior only depends on the current situation. However, customer preferences are typically influenced by past situations and experiences. To address this limitation, future research may introduce conditional probabilities that include multiple past states. Third, in its current form, the decision model does not cover all possible parameters of the switching matrix, the restriction matrix, and the configuration costs. The switching matrix only covers switching from one channel to another. However, switching values, which represent the likelihood that customers switch from one channel to another, may differ for each process step. The restriction matrix only covers restrictions on process steps, abstracting from potential differences among channels. Then, we assumed that configuration costs are identical for each process step and channel. We accepted these limitations to strengthen the applicability of our decision model, focusing on those parameters with the highest effects.

When applying our decision model to the real-world data of a German bank, we only determined the best OCS for a single service offering, namely construction financing. In general, organizations have several product or service offerings, which differ in terms of their monetary effects and CJs. Because channels are available for all products and services once they have been established, it is important to consider all offerings to ensure an integrated perspective of an organization's omni-channel environment. However, mapping CJs for one offering is already complex. For this reason, our application focused on one offering in order to validate how the decision model behaves in a real-world setting. Nevertheless, the decision model can be easily extended to account for several offerings (e.g., by adding more PDP steps). Moreover, the main difficulty of applying our decision model relates to estimating the required input parameters, such as conversion or switching rates. Thus, we recommend conducting additional case studies in different contexts to get a better understanding of potential value ranges for these parameters, and to establish a reliable knowledge base. Finally, to evaluate the applicability of our decision model, we implemented a software prototype. Thus far, this prototype supports research activities, but is not user-friendly enough to be applied in many different settings. When conducting multiple case studies, the prototype should be further developed in terms of more sophisticated analysis functionality (e.g., scenario and sensitivity analyses) and a convenient user interface.

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Appendix

Conversion rates serve as an additional input data for the real-world case. In our case, the conversion rate matrix is a 63×63 matrix. In Table A.1, we only display conversation rates that differ from zero.

Table A.1 - Conversion rates of real-world case