Understanding the E-Banking Channel Selection Behavior of Elderly Customers:
A Small-World Network Perspective

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ABSTRACT

To reveal the influence mechanism of e-banking channel selection of elderly customers, according to the analysis of elderly customers'decision-making process, a threshold model is proposed by using small world customer relationship network and variable setting in this study. The multi-agent simulation of e-banking channel selection behavior of elderly customers is carried out from the perspectives of channel diffusion speed and customer channel selection proportion in the context of the COVID-19 pandemic. The research shows that channel performance and individual differences of customers affect the adoption of e-banking by elderly customers. This study also has found that network size and network density can regulate the impact of channel performance on the selection behavior of elderly groups. However, they could play a regulatory role under certain conditions. Finally, this study puts forward some suggestions to improve the channel diffusion efficiency, such as building an elderly friendly e-financial service channel and construction of elderly business market culture.

KEYWORDS

Channel Selection Behavior, E-Banking, Elderly Customers, Small World Network, Threshold Model

1. INTRODUCTION

During the Covid-19 pandemic, measures such as social isolating and national quarantines led to restrictions on the movement of people. These restrictions influence the operation of many sections, such as tourism, banking and finance (Gerwe, 2021; Borri & Giorhio, 2021). To mitigate the spread of the Covid-19 virus, closed physical contact is discouraging in service-oriented businesses. For example, in the banking industry, face-to-face customer services came to a near-standstill in developing economies due to human movement restrictions (Chirisa et al., 2020). In addition, people are more vulnerable to infection when they encounter a face-to-face service, since the means of spreading the virus is mainly human-to-human contact. Therefore, many customers are reluctant to go to banks offline to prevent being infected. As a remedy, banking must provide digitally enabled services or platforms.

In developed countries, a dramatic development in financial technologies is changing the way people shop, save, borrow, and make financial decisions (Economides & Jeziorski, 2017). Meanwhile, the information technology revolution has created extraordinary new opportunities for the banking industry in developing countries to address challenging issues concerning operational efficiency, marketing channels, and the technological environment (Kaur & Ali, 2021). Increasing numbers

of people use financial technology in China, where the new technologies have been widely used in financial services or financial products marketing, such as Internet banking, telephone banking, mobile banking. We collectively refer to these digitally enabled services as e-banking (electronic banking). Especially during the Covid-19 pandemic, people are more dependent on e-banking channels than before since they are more worried about their health. Banks' increasingly rich service channels have provided more choices for customers to obtain financial services, and changed the Chinese banking industry's traditional operation models and marketing concepts. Under the new financial ecology, deep integration of information technology, active integration of financial science and technology, digital transformation and innovative development are essential ways for the sustainable development of Chinese commercial banks.

Currently, the conception of e-bank has been recognized and accepted by more and more young user groups. However, China is experiencing the fastest aging process. According to CSY report, elderly people aged 65 and above have increased from 62.99 million in 1990 to 88.11 million in 2000. In 2021, it has reached 190.64 million, accounting for 13.50% of the total population. It is estimated that by 2040, the proportion of the population aged 65 and above will exceed 20%(CSY,2021). Financial activities of the senior citizen, referring to as the elderly customers in this study, have been ignored by existing literature. Since the elderly are unfamiliar with online banking and have limited ability to learn new things, they are not willing to accept and even refuse e-banking. As a result, they are more inclined to go to outlets to handle financial business and encounter a face-to-face financial service. However, bank financial services have an essential impact on the life of the elderly (Oinas-Kukkonen, 2010; Guido et al., 2020). E-banking services are essential for all people; moreover, they play an increasingly important role in the elderly(Msweli & Mawela, 2020). Therefore, it is necessary to explore how to attract the elderly to engage with e-banking services.

Unquestionably, problems such as the 'digital divide' and 'intelligence barrier' have created obstacles in the daily lives of the elderly. These problems are attracting attention from scholars and practitioners. Against this background, this paper investigates how to provide targeted and diversified banking services for the elderly based on information technology. It is of significance for the sustainable development of banking and for society to encourage the elderly to adopt disruptive technology and adapt to the rapid development.

2. LITERATURE REVIEW AND RESEARCH DEVELOPMENT

2.1 Research On The Value Of E-Banking Channels And Customer Channel Selection

E-banking technology has made remarkable progress (Takieddine & Sun, 2015; de Reuver et al., 2015). The explosive development of e-banking has prompted relevant researchers to pay attention to the channel value of e-banking and the behavioral motives of the customers' selection of the e-banking channel . At present, the e-banking channel has become an important strategy for obtaining a competitive advantage in banking services (Kiboori, 2017). Hitt and Frei (2002) studied the difference between e-banking customers and traditional channel customers from a statistical perspective and found that e-banking customers generate higher profits and have higher retention rates. Xue et al. (2007) included customers' perception of channel use in their study and believed that improved efficiency in electronic channels would enhance the banks' overall profitability. They further investigated the driving factors for choosing e-banking and pointed out that higher transaction demand, efficiency, and local penetration are the main motivations. Campbell and Frei (2010) studied customer channel preferences after choosing e-banking and found the substitution effect of e-banking on self-service channels, including automatic teller machines (ATMs) and telephone-based voice response units (VRUs). Many studies have investigated the antecedents of internet banking and mobile banking adoption (Khedmatgozar, 2021; Malaquias et al., 2018; Gikandi & Bloor, 2010; Rouhani

et al., 2018; Huang, 2017; Sharma et al., 2020). Further, Tam and Oliveira (2019) investigated the influence of culture on mobile banking use and individual performance. Liang and Nguyen (2018) discussed marketing strategies of internet-banking services from the perspective of service quality. After choosing e-banking channels, strengthening financial management and control will increase customers' willingness to use all bank channels and increase transaction volume through these channels (Inegbedion et al., 2019). Hernando and Nieto (2007) further verified these conclusions and found that banks use e-banking to supplement physical branches rather than as a substitute.

The existing literature mainly focuses on the influence of electronic channels on the customer behavior of brick-and-mortar channels, and some research also discusses the impact of brick-and-mortar stores on retailers' online sales (Pauwels and Neslin,2015; Wang and Goldfarb,2016; Bell et al., 2018). In addition, some scholars have explored the problem of user channel selection based on channel advantages. Choudhury and Karahanna (2008) pointed out that the Internet may fundamentally change the marketing channel structure, but only if customers choose to adopt electronic channels. They note customers make channel adoption decisions primarily based on their cumulative assessment of the comparative advantage of channel innovation (convenience, trust, and effectiveness of access to information). Zarifis and Kokkinaki (2015) explored the relative advantages of collaborative virtual environments and two-dimensional websites in multi-channel retailing from the customers' perspective. They analyzed the characteristics of various channels, consumer preferences at the purchase stage, differences between simple products and complex products, and the role of trust. Zarifis (2019) evaluated the relative advantages among the 3D virtual world, 2D websites, and offline retail stores, and the results showed participants preferred offline and 2D in most situations. The exceptions were where the Virtual Worlds were preferred, as they provided more enjoyment, entertainment, social shopping, the ability for reinvention, convenience, and institutional trust. In addition, because of the different nature of transaction types in the banking and retail industries, the underlying mechanisms behind the channel behavior of customers may be completely different. For example, in a retail environment, physical stores may promote online sales thanks to the return effect, meaning that physical stores can reduce customers' risk of buying online by providing the option of store returns (Kumar et al., 2019). This mechanism is unlikely to affect the banking environment, as transactions such as payment investigation may be influenced differently by bank transfers. Therefore, when applying the research results of the retail industry to the banking industry, careful consideration is needed. In a complex channel environment, the wise decisions made by bank managers on the reorganization of the branch network depend primarily on a comprehensive understanding of the various behaviors of banking customers.

2.2 Channel Service And Customer Choice Behavior

Industrial digital transformation is the engine of China's economic growth, of which the improvement of information technology innovation capabilities is the key. Rigby pointed out that, with the advent of the digital age, companies need to interact with customers through multiple channels to seamlessly connect the customer experience (Rigby, 2011). In the process of channel service, the business development of enterprises is influenced by customer preferences, channel performance, and experience technology, so it is necessary to combine enterprise product characteristics with channel performance to match customer demand (Chopra, 2018). Furthermore, with the integration of information technology and communication technology, mobile devices, and mobile Internet are widely used in home shopping. Therefore, various new channels bring new development opportunities for retailing and complicate the development of sales strategies (Xu & Jackson, 2019). If electronic channels want to achieve better integration with the omni-channel environment. In that case, retailers should also consider the type of products to be sold at the same time to target the transmission of information to customers through channels, which requires a comprehensive understanding of customer channel selection behavior, clear customer channel preferences of heterogeneity, and customer selection behavior factors, as a basis for the development of enterprise marketing strategy (Chopra, 2018).

In the research on channel performance and customer selection behavior, Xu and Jackson (2019) hold that channel characteristics are trigger factors as external factors, including channel transparency, channel convenience, and channel consistency. External factors indirectly affect customers' channel selection through internal factors such as customer perceived behavior control and perceived risk. Therefore, channel service providers should provide customers with high-performance channels to help customers obtain personalized services, help customers understand how to use channels, and integrate different channels to meet their consumption needs (Shen et al., 2018). From the individual customer's perspective, impulsive shoppers tend to use mobile devices, while people with high demand for touch use online devices during the shopping process (Rodríguez-Torrico et al., 2017). The more customers pay attention to convenience rather than cost and environment, the more likely online information and door-to-door delivery channels are to gain greater market share. On the contrary, if customers pay more attention to immediate satisfaction, the channel must be located closer to customers (Chopra, 2018). Kazancoglu and Aydin (2018) found that customers perceived security and usefulness as the critical determinants of purchase intention and personal innovation. Customer habits have a moderating effect. Other scholars proposed that the influencing factors of customers' channel selection behavior also include age and gender (Parks & Lee, 2017), past purchase behavior, shopping experience, and their social relationship network (Verhoef et al., 2015).

2.3 Research On Financial Services For The Elderly

In a highly developed society, an aging population will transform customers' financial needs. Oesch (2009) believes that financial institutions should enhance communication with customers and service experience when handling the business of the elderly customers and provide customers with diversified financial services and products on this basis. Schultz et al. (2000) concluded that the success of U.S. banks in providing elderly customers with financial services lies in the establishment of a wide range of institutional alliance platforms and a variety of investment options. For banks, it is necessary to adopt measures to understand customer needs accurately, diversify service methods, enrich products, provide convenient service solutions for special customer groups (such as elderly customers), and strive for the market share and position of elderly customer groups(Meresht, 2019).

Due to the limited cognitive ability of elderly customers, their attitude towards new banking channels is often conservative. Modigliani and Cao (2004) conducted empirical research using data about the population savings rate. Their findings showed that an aging population increases household savings, and they conclude that the elderly are risk-averse. Therefore, for new e-banking channels, the acceptance speed of elderly customer groups is generally slow. With the continuous economic development in some developing countries, the elderly also began to pay attention to financial management. This phenomenon increased the demand for financial services. Therefore, it is necessary to strengthen the financial knowledge of the elderly and provide professional training to help them learn financial skills and become more risk-consciousness.

After reviewing the existing literature, we can find that the fundamental difference between the product-based market and the service-based market may lead to entirely different potential mechanisms for customers' channel selection behaviors. From the perspective of new technology adoption, most scholars agree that there are differences between the adoption intention and behaviors of different customer groups regarding e-banking channels (Lee & Kim, 2010; Alalwan et al., 2017; Sinnappan et al., 2022). Therefore, it is necessary to study the e-banking channel selection behavior of elderly customers in the complex environment under the background of the rapid development of information technology and the growing elderly population. Although there is a large body of literature on retail channel selection, there are few dynamic analyses on the customer group selection behaviors of bank channels, especially the selection behavior of the elderly customer group. At present, the dynamic process of bank channel selection behavior is still in the exploration stage. Based on the exclusive research framework and mathematical model, future research will focus on using cutting-edge simulation and analysis tools to study the dynamic process of e-banking channel selection behavior of

elderly customers and explore their behavior dynamics. Therefore, this study focuses on the e-banking channel selection behavior of elderly customers.

This study is based on the small-world network theory and uses the multi-agent simulation method to explore the e-banking channel selection behavior and influencing mechanisms for the group of elderly customers. The channel performance is used as the key variable and the network structure of the elderly customer group as the regulating variable. It constructs the threshold model of the elderly customer channel adoption process. As such, this study provides a theoretical basis for banks to improve bank service efficiency and formulate optimal marketing strategies based on the needs of elderly customers. It provides solutions for banks seeking to enhance their relationship management with elderly customers and improve their economic benefits.

3. ANALYSIS OF NETWORK ENVIRONMENT AND CUSTOMER DECISION-MAKING PROCESS

The activity circle of elderly customers is relatively fixed, and they contact each other in life mainly through offline social and community activities. Therefore, there are usually clear boundaries among the elderly communities. However, the information transmission speed among the elderly community is generally fast, and they can form close relationships to form an acquaintance relationship network based on different communities. The correlation characteristics of the elderly customer groups are used in this paper with the network analysis method based on the complex network theory to study the e-banking channel selection behavior of the elderly customer group.

Complex network theory is a branch of complex system theory. Compared with traditional analysis methods, the complex network analysis method has advantages in managing complexity in social and economic systems. It abstracts various social and economic systems into the network topology structure of nodes and the relationship between nodes, which can be used to examine and analyze the decision-making of the main body and the macro-dynamic behavior of interactions between the main bodies. From this, the general law of the development of the social and economic system can be extracted. This approach is consistent with the idea of the e-banking channel selection behavior of the elderly customer group. Therefore, to study the phenomenon from the perspective of complex networks can allow us to examine and understand the micro-adoption mechanisms of elderly customers' selection behavior. On the other hand, considering the complex characteristics of the elderly customers' behavior can help us to analyze the related problems of the proliferation of e-banking channels and more scientifically analyze the selection behavior of elderly customers. In addition, the application of complex network theory to the research expands the cross-integration of complex network theory and presents broad research prospects.

3.1 Network Structure Setting

From the perspective of various complex network types, based on the characteristics of the composition of the elderly customer group, the relationship network composed of elderly customer groups does not belong to the category of completely random networks and regular networks, nor does it have the preferential connection principle similar to scale-free network. Instead, it is similar to the structural characteristics of small-world network; i.e., characterized by a high agglomeration coefficient, strong connectivity, and a short average path (Piazzi & Baggio, 2012).
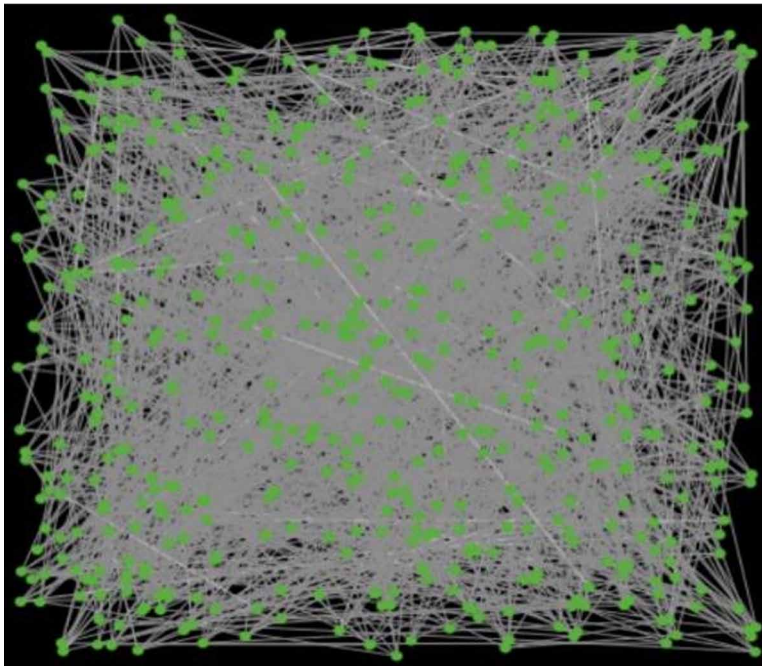
We can regard elderly customers in the bank channel as nodes in the social network, and the relationship network composed of nodes has the characteristics of a small world. When analyzing the relationship between e-bank channel proliferation and elderly customer selection behavior, this paper takes small-world network as the network structure of elderly customer selection behavior in the e-bank channel. It uses the small-world network as the basic structure to adjust network scale and network density to analyze the pattern of elderly customer selection behavior. Watts and Strogatz (1998) proposed a small-world network with a structure closer to the real-world network, with a

shorter average distance and higher aggregation coefficient structure, the WS small-world model. There are two WS network generation rules. First, establish a complex network with N nodes and D as the average degree value, all nodes are connected to K/2 ($K \in 2N$ and $N^3K^3\ln(N)^31$) nodes adjacent to themselves. Second, randomly select an edge so that one end will randomly reconnect to a new node with probability P (excluding neighbor nodes). Any two nodes in the network are only connected to the edge without forming a circle because we can calculate that there are pNK/2 long-range edges on the network side. From the WS network generation algorithm, it can be known that the reconnection probability range of the WS network is 0<P<1 (P=0 is a regular network, P=1 is a random network).

This study used Netlogo software to build a small-world network model. We set the number of nodes to 1000, which means that there are 1000 potential e-bank channel selection subjects (i.e., elderly customers) in the e-bank's channel proliferation network. The e-bank's channel proliferated among the 1000 subjects, assuming that each subject has no isolated nodes. Then, based on the sparsity principle, we set the average degree to 6 (each subject has an average of six neighbors), set the average clustering coefficient to 0.5, and the reconnection probability P to 0.12. The WS network model constructed from this is suitable for the actual situation. The final generated WS network diagram is as follows.

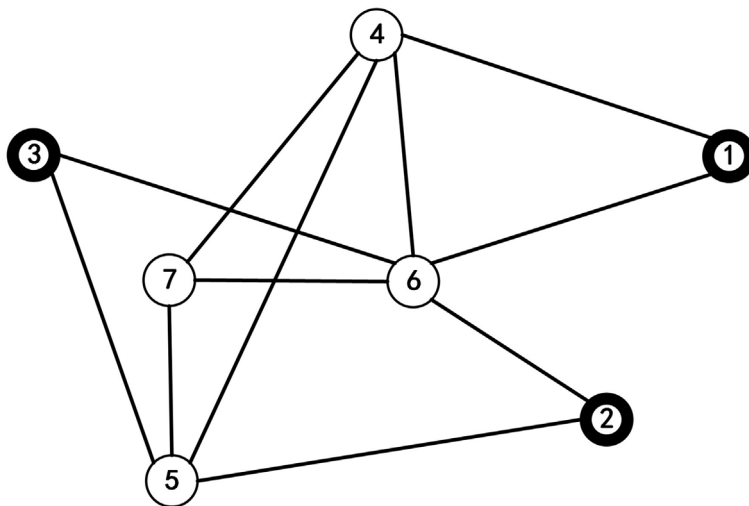## 3.2 Network Externality And Domino Effect

Figure 1. Diagram of the small world network structure

With the increase of elderly customers, the utility of choosing an e-bank channel increases, and the value of an e-bank channel increases exponentially. The value of e-bank channels to elderly customers depends on the number of elderly customers using e-bank channels in the network. This phenomenon is called the network effect (Katz & Shapiro, 1985). The utility of elderly customers obtains from choosing the e-bank's channel is affected by the network effect, which is the decisive factor of elderly

customer selection behavior. According to the scale of impact, network effects can be divided into global and local. The global network effect means that the number of elderly customers affects the utility, while the local network effect means that the utility is only affected by the number of elderly customers in a specific area. In a real setting, the network effects that elderly customer feels wrong or uncertain about mainly stem from their relationship network rather than the market relationship network. Many studies have confirmed that the local network effect is the key factor that affects the elderly customers' selection behavior(Sundararajan, 2005; Yeung et al., 2006; Czajkowski & Sobolewski, 2016). This paper uses the 'social signal' value function to measure the local network effects elderly customers' experiences. We express the intensity of social signals as the proportion of the number of elderly customers who have selected the e-bank's channel in the subject's neighborhood to the total number of subjects in the neighborhood. As shown in Figure 2, Node 1, Node 2 and Node 3 represent the individuals who have selected the e-bank's channel. Nodes 4, 5, 6, and 7 represent individuals who have not selected the e-channel (i.e., the channel from the e-bank) and then the neighborhood of node 6 is five. In this neighborhood, three nodes have selected the e-bank channel (i.e., node 1, node 2, and node 3), then the social signal influence intensity of node 6 at this moment is 3/5. For node 7, since no individuals are choosing the e-bank channel in its neighborhood (node 4, node 5, and node 6), the social signal intensity is 0. The more an individual is affected by social signals, the greater the network externality. The individual will change his behavior to be consistent with the network's group selection behavior.

Figure 2. Diagram of the local network effect of customer selection behavior

When the e-bank channel enters the early senior market, initial elderly customers are independent, random, and have a certain scale. An elderly customer group is formed under the network externality. We generate these initial stage elderly customers based on the exogeneity of the e-bank channel. Subsequently, these initial elderly customers will further influence the selection behavior of the surrounding nodes (such as friends or acquaintances) through their respective neighborhoods, giving rise to the first group of endogenous customers. After that, it will also form the second group of endogenous customers through their respective neighborhoods. The cycle repeats until no new

customers appear and the selection behavior ends. This phenomenon is called the domino effect. Based on network externality and the different scales of dominoes, it can be divided into local and global dominoes. There should be enough connections among early adopted elderly customers for the e-bank channels to establish a critical initial group. Only then the domino effect can continue and eventually form an overall domino. Otherwise, the e-bank channel cannot achieve global proliferation. Although the critical group may only account for a small part of the total number of elderly customers, it is a crucial factor in the domino effect. By adjusting the network parameters to set up networks with different domino characteristics, this paper further studies the pattern of elderly customer selection behavior in the e-bank channel environment.

The e-bank channel type determines the activation scale of the critical adoption group. Therefore, the influence of social signals on elderly customer selection behavior and customers' perception of the e-bank channel performance can reflect the applicability of the e-bank channel, which determines whether the elderly customer scale can be activated and triggers a domino effect. Therefore, the network characteristics play an important moderating effect. This study used the network characteristics as the moderating variables and divided the network characteristics based on the dominant attributes into two dimensions: network scale and network density. First, the network scale refers to the number of nodes. If other conditions remain unchanged, whether the size of the network affects the proliferation of e-bank channels and how they work are issues that banks will often face in the decision-making process of electronic channel operations. Second, network density refers to the closeness between nodes and mainly measures the gap between the total distribution of node edges and the fully connected graph (Dempwolf & Lyles, 2012; Lin, 2019).

Based on this, the study adjusts the number of network nodes and the closeness between nodes to analyze the changes in elderly customers' behaviors under different network structure characteristics. Therefore, it analyzes the relationship among the e-bank channels, network scale, network density, and elderly customer selection behavior.

3.3 Customer Decision-Making Process

According to the theory of consumer purchasing decision-making, customers generally go through three processes in selecting and decision-making of the bank's channel: information collection, utility evaluation, and behavioral decision-making. 1) information collection. Elderly customers demand electronic channel banking for financial needs and other reasons. They will pay attention to or look for relevant information. Information sources mainly include personal sources (such as acquaintances, neighbors, and friends) and public sources (including advertising, dealers, and mass media). Public sources spread a wide range of information to customers like a 'pulse,' but the information is extensive and less targeted. Information from personal sources has a limited scope, but it is more detailed and spread mainly through daily contact. Elderly customers form a preliminary judgment of the e-bank channels through the process of collecting information. The time they spent learning the desired information is closely related to the intensity of public source information dissemination, the aggregation of personal source information, and the intensity of interaction between individuals.
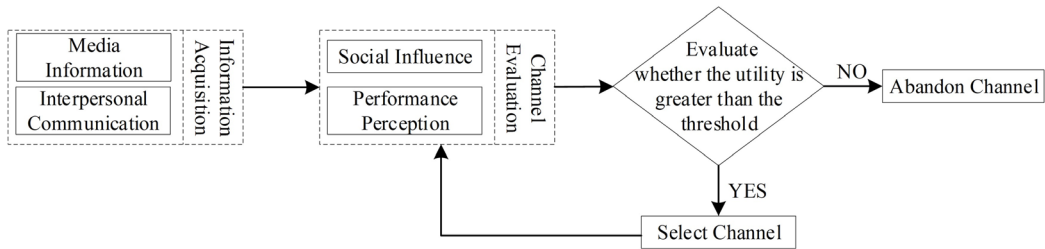
Second, elderly customers evaluate the utility of different selection behaviors. They will only decide when the utility is greater than the cost of selection. Elderly customers' evaluation of the bank's e-channel utility mainly includes two parts. First, the perception of performance brought by electronic channel attributes (including convenience, safety, complexity and cost). The better the attribute, the higher the utility. The second is the 'normative influence,' which comes from pursuing self-recognition and the realization of personal value in the social network of the elderly customer. For example, with mobile banking electronic channels becoming popular, elderly customer's recognition of how their value in social networks will be adversely affected if they do not use it. The more people choose a certain channel in the social network, the greater the normative influence on the individual customer;

Third, the behavioral decision-making in the decision-making process. Elderly customers will possess the highest decision-making cost they are willing to bear; this is the lowest expected utility

of the bank's e-channel, called the channel selection threshold. When the expected utility is less than the channel selection threshold, the customer will abandon the bank's e-channel and vice versa.

4. MODEL BUILDING

Figure 3. Micro-mechanism of customer selection behavior based on the social network

The threshold model originated in social science research. It is used to describe whether an individual decides whether to join the collective behavior and the proportion of individuals who join the collective behavior. It is a classic model to explain group behavior. It means that the individual's decision-making behavior is affected by the positive feedback from interacting with the surrounding people. The more individuals participate in the collective behavior, the greater the influence of the collective. Therefore, many individuals will choose the collective behavior, further intensifying the collective influence. 'Individual herd tendency' is used as a decisive parameter of the control variable for the escalation of collective scale caused by individual participation in collective behavior. It is set so that when the value of 'individual herd tendency' exceeds a threshold, the individual participates in collective action. Different individuals may have different social backgrounds, behavior motives, benefits, and payments, indicating that the threshold of individual behavior is heterogeneous. Arrange the individual herd tendency thresholds from small to large to form a 'participation in decision-making' curve. The minimum (i.e., the lowest threshold) is the first to decide to participate in collective activities. According to this rule, the rest of the individuals will consecutively participate. It can be inferred that the minimum value of the curve can represent the collective behavior threshold of the group. Individuals with a lower threshold are called radicals. Those with a threshold of zero are promoters. Individuals with a higher threshold are called conservatives.

Threshold models have been widely used to simulate various social phenomena. To address 'global information' (which contradicts reality), scholars introduced local network effects to modify the threshold model and limit individuals to only acquire the local information embedded in the network. The network effect produced by local social influence strengthens with the increase of the number of individuals who adopt the same product or compatible products, that is, network externality. However, it should be noted that network effects are not necessarily an increasing function of social influence. The network effect will diminish for individuals who like to be unconventional as the social influence increases.

This paper constructs a threshold model of elderly customer group selection behavior in an e-bank channel environment that includes a mental threshold. A mental threshold is defined as the critical point to perceive qualitative changes, which describes the relative stability of the individual's feelings, and changes only when external stimuli reach a certain level. From the perspective of mental threshold, this paper models the cluster dynamic process of bank elderly customers in the e-channel

environment. Therefore, it explains how elderly customer channel selection behavior is triggered by the stress response of the e-bank channel's environment exceeding the threshold. The selection behavior occurs regardless of whether this stress comes from external information, self-learning, or factors such as group pressure. From the perspective of economic utility theory, elderly decision-makers can be explained based on weighing benefits, payments, and corresponding thresholds.

In this paper, the steps of constructing the threshold model of elderly customer group selection behavior in the bank's e-channel environment are as follows:

(1) Utility function

According to the utility theory, whether a customer chooses an e-bank channel depends on the trade-off between benefits and payments. Due to the different utility, the threshold of elderly customers participating in group behavior is different. Therefore, the elderly customer utility function under the e-channel environment of the bank is constructed as:

$$U_i = B_i - M_i + V\left(s_i\right) + G_l$$

Among them, Ui represents the utility of i individuals participating in group actions; Bi represents the benefits obtained by i participating in group actions, Mi represents the cost of i participating in group actions; si is a social signal, which represents the local social influence that the individual receives, that is, the group information observed from the local part of the social network. The information source includes interpersonal communication and media transmission; $V\left(\circ\right)$ is a value function defined based on social signals, representing the network effect observed by i individual, and Gl is the bank's e-channel performance. $l=l1+l2+…lm$

① Social signal expression:

$$s_i = \frac{\sum_{j\in n_i} a_{ij} A_j}{n-1}$$

ni is the area of i; aij means j's signal influence intensity on i. $Aj=0$ means that j does not choose bank e-channel; $Ai=1$ means that j has selected bank e-channel.

② Value function expression:

$$V\left(\circ\right) = 1 - e^{-\eta\circ} \left(\circ \geq 0\right)$$

η is the risk aversion parameter, which represents the network effect that strengthens with the increase of group participants.

(2) Activation mechanism

Among them, *Ait* represents the e-channel banking selection status of customer *i* at time *t*. When *Ait* =0, it means that the elderly customer *i* did not choose the e-channel bank at time t. When *Ait*=1, the elderly customer *i* has chosen the e-channel bank at time t. *Hit* is the total utility elderly customer *i* gets by selecting a certain bank e-channel at time t, and *Hht* is elderly customer *i*'s selection threshold. When *Hit<Hht,* it means that the total utility *Hit* of bank customer *i*'s selection of bank e-channel at time t is less than the customer's selection threshold. Therefore, elderly customer *i* will not always choose bank e-channel at time t. When *Hit³Hht,* it means that the total utility *Hit* obtained by the elderly customer *i* who chooses the e-channel bank at time t is greater than or equal to the selection threshold of the elderly customer, then the elderly customer *i* chooses the e-channel bank at time t.

(3) Threshold model

$$W_i = \int_{E_i}^b w_i m(x)\, dx$$

Wi is the individual *i*'s utility perception level, which represents the difference between the expectation for e-channels and the actual experience. *Ei* is the expectation, meaning the psychological threshold of the individual *i* participating in group actions; *wi* is the satisfaction level, meaning the individual's perception level of participating in collective actions. The herd tendency's distribution threshold is *Ti~f(x),* meaning that when the individual's utility perception *Wi>Ti,* *i*'s e-channel selection threshold is activated, otherwise, *i* won't select e-channel.

① Satisfaction

$$w_i = U_i - E_i$$

If *wi>0,* it means that the actual utility of choosing e-channel is greater than its psychological expected utility threshold *Ei.* From the perspective of utility, the individual *i* will choose the e-channel, and *Ei* obeys the even distribution on [a, b].

② herd tendency

$$r(t) = F\big(r(t-1)\big)$$

r(t) represents the percentage of customers participating in group behavior at time t. The group behavior threshold probability distribution is *f(x),* then the cumulative probability distribution function is *F(x)*, $F(x) = \int_0^x f(x)\, dx$ represents the percentage of individuals whose threshold value is less than or equal to x in the group. When r(t)=r(t-1), collective action has reached equilibrium.

5. SIMULATION ANALYSIS

Based on the research topic, this paper uses multi-agent simulation method, several corresponding simulation scenarios, and various parameters based on the Netlogo 6.2.0 simulation platform.

5.1 System Environment Setting And Simulation Parameter Setting

Create the subject Turtles, initialize the status of all subjects to 'not choosing bank e-channel,' and assign customers relevant attributes, including signal influence intensity, risk aversion, herd tendency threshold, number of customers, operating frequency, channel type and other environment settings. To analyze the impact of performance changes from low to high under different network scale conditions on the results of customer selection behavior, the bank's e-channel performance is set from low to high to 0.25, 0.45, 0.55, and 0.65, which represent low, relatively low, relatively high, and high performance. And this paper conducts the simulation analysis under the scenario in which network scale (number of nodes) is 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000; network density of 0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.01, and observe the proliferation speed of e-channel in customer groups and the proportion change of customers choosing e-channel. This would help to comprehensively reveal the multiple influence relationship among e-channel, network characteristics and elderly customer selection behavior. The parameter settings are shown in Table 1.

5.2 Simulation Rules

Table 1. Parameter settings

variable	parameter	Value range
bank e-channel performance	*Gl*	N~ (0.70, 0.01)
channel type	*z*	(1, 4)
signal influence intensity	*aij*	N~ (0.35, 0.01)
risk aversion	*η*	N~ (0.50, 0.01)
herd tendency	*Ti*	0.003
customer numbers	*Agent-number*	1000
steps	*Run-times*	500
network scale	*N*	100;200;300;400;500;600;700;800; 900;1000
network density	*d*	0.001;0.002; 0.003;0.004; 0.005;0.006; 0.007;0.008; 0.009;0.01

(1) system initiation. Elderly customers' e-channel selection behavior is triggered by external factors, and continues to be promoted mainly by internal influences. The social signal transmission effect initiates the simulation in this paper.. When the social signal affects the first group of elderly customers, the e-channel related information spreads, and the system operates.

(2) marking update. In each time step, all customers will evaluate the expected utility of the selected e-channel based on the threshold function. When the expected total utility of the elderly customer's selection is greater than the adoption threshold, the individual will be marked as 'select e-channel,' otherwise the mark will be marked as 'do not select e-channel.' When all elderly customer markings are updated, the next time step is followed, and all elderly customers will re-evaluate utility and update the markings. The steps go on.

(3) operations cease. When the social signal is transmitted to all customers, and the mark of all customers is no longer updated, that is, when r(t)=r(t-1), the system will stop running otherwise the system will run the rules repeatedly until the elderly customer's selection behavior cease.

5.3 Result Analysis

Based on the above parameter settings, 100 iterations are performed for each parameter condition, and the average value of the 100 iterations data is taken as the final result to minimize the interference of randomness on the simulation results. From the two aspects of network scale and network density, the simulation data of bank's e-channel proliferation speed and elderly customer selection ratio are sorted, graphed, and analyzed, as shown in the figure.

Figure 4-a Channel proliferation speed (network scale)Figure 4.-b Customer selection ratio (network scale)Figure 4.-c Channel proliferation speed (network density)Figure 4.-d Customer selection ratio (network density)
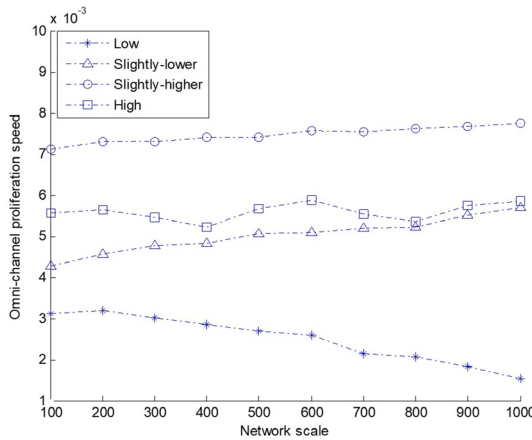

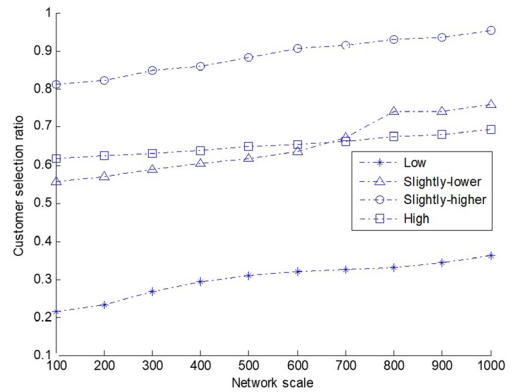Figure 4-a Channel proliferation speed
(network scale)

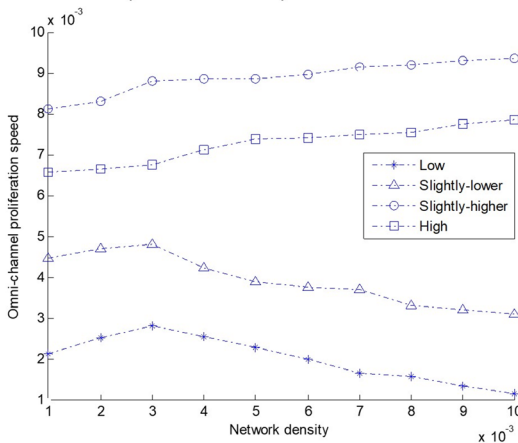Figure 4-b Customer selection ratio
(network scale)

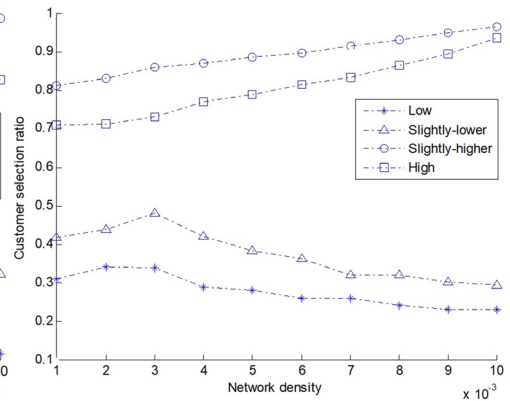Figure 4-c Channel proliferation speed
(network density)

Figure 4-d Customer selection ratio
(network density)

(1) Analysis of the relationship among e-channel performance, network scale and e-channel proliferation speed

It can be seen from Figure 4-a that in the range of channel performance from low to high, no matter how the network scale changes, improving channel performance can correspondingly increase the proliferation speed of the bank's e-channel. However, when the channel performance is too high, channel performance is not significantly positively correlated with channel proliferation speed. For example, when the bank's e-channel performance is high, the bank's e-channel proliferation speed is significantly lower than the situation in relatively high channel performance, indicating that a certain threshold exists in channel performance's influence on the channel proliferation speed. In addition, with the expansion of the network scale, the e-channel proliferation speed under low channel performance exhibits a downward trend, and the proliferation speed has always been at a low level.

The magnitude of its change gradually decreases with the expansion of the network scale, which shows that the network scale where bank customers are located under certain conditions can regulate the relationship between channel performance and channel proliferation speed.

(2) Analysis of the relationship among the elderly customer selection ratio, e-channel performance, and network scale

It can be seen from Figure 4-b that in the range of channel performance from low to high, as the network scale gradually increases, the proportion of elderly customers choosing e-channel will increase to varying degrees. The change indicates that within a specific range the network scale positively affects the elderly customer selection ratio. Specifically, in the proliferation of low-performance omni-channel, the elderly customer selection ratio will increase with expanding the network scale. Furthermore, in a particular network scale, the elderly customer selection ratio will exceed that of high-performance e-channel. As the network scale expands, the selection ratio of relatively low performance omni-channel gradually decreases, and tends to be stable. This outcome shows that there is a threshold that affects the e-channel selection ratio under different network scales. Expanding the network scale increases the selection ratio if the network scale is smaller than this threshold. Conversely, expanding the network scale reduces the selection ratio when the elderly customer network scale exceeds this threshold. For a relatively high-performance e-channel, the customer selection ratio is the highest from low to high network scale, which indicates that banks can focus on developing high-performance channel promotion strategies under the condition of limited resources. For banks with high-performance e-channels, the elderly customer selection ratio increases with the upscale of the network. The overall increase is not prominent but remains relatively stable. In addition, in the proliferation of low-performance bank e-channels, the customer selection ratio has always been at a low level, and with the expansion of the network scale, the ratio will also exhibit a downward trend.

(3) Analysis of the relationship among channel performance, network density, and channel proliferation speed

It can be seen from Figure 4-c that when the channel performance remains relatively high, the proliferation speed of the omni-channel shows a gradual upward trend as the network density increases. However, for banks with low performance and relatively low performance, the bank's e-channel proliferation speed will show a downward trend as network density reaches a certain level. This relationship shows that network density is not always positive for the bank's e-channel proliferation speed. When the network density is high, proliferation speed will decrease. Furthermore, under the same network density, the e-channel proliferation speed of relatively high performance is faster than that of high, relatively low, and low performance. Banks with low performance have the lowest

proliferation speed among these four types. The difference in proliferation speed exhibits a trend of first expanding and then shrinking as the network density changes, indicating that the network density has a regulating effect on the channel performance's influence on the bank's e-channel proliferation speed. When the network density is low, increasing the network density can amplify the bank's e-channel performance on the bank's e-channel proliferation speed. When the network density is high, the network density has a moderating effect on the relationship between the bank's e-channel performance and the bank's e-channel proliferation speed, but is not significant.

(4) Analysis of the relationship among channel performance, network density and channel customer selection ratio

It can be seen from Figure 4-d that under the high performance and relatively high-performance e-channels, the customer selection ratio gradually increases with the increase of network density. In contrast, under low performance and relatively low-performance e-channels the customer selection ratio exhibits a trend of first increasing and then decreasing. Regardless of the network density, the elderly customer selection ratio for relatively high performance is the largest under the same network density, followed by high, relatively low-performance e-channel. In addition, with the increase of network density, the selection ratio of high and relatively high-performance e-channel gradually approaches and eventually converges. But the selection ratio of low performance and relatively low-performance e-channels gradually diverges from that of high- and relatively high-performance channel. This divergence indicates that when the e-channel performance is at a high or relatively high level, increasing the network density can reduce the performance's impact on customer selection ratio and further magnify the different impacts on the customer selection ratio of low, relatively low, relatively high and high performance omni-channel.

6. DISCUSSION AND CONCLUSION

6.1 Discussion of Findings

This paper first analyzes elderly customer selection behavior from three aspects: elderly customer relationship network based on multi-agent selection behavior, media information, and elderly customer group characteristics. Then, the elderly customer network structure is used as a moderating variable for the research of customer selection behavior in the e-banking context. This paper establishes a threshold model based on the analysis of the decision-making process of elderly customer selection behavior, and conducts multi-agent simulation from 2 perspectives, namely the proliferation speed and the customer selection ratio. The simulation results reveal the mechanism for optimizing the elderly customer group selection behavior in the bank's e-channel environment. Finally, the following conclusions are drawn in this study.

First, in the small-world elderly customer relationship network, channel performance is a key factor affecting the group selection behavior of the bank's e-channel. In addition to channel performance (an objective factor), subjective factors will also affect group selection (the effect of channel proliferation) such as individual characteristics, preferences, and perception abilities. Specifically, from low to relatively high e-channel performance, there is a positive correlation between channel performance, bank e-channel proliferation speed, and elderly customer selection ratio. Nevertheless, from high to relatively high e-channel performance, channel performance's effect on the e-channel proliferation is not positive. Therefore, excessive channel performance may hinder the bank's e-channel proliferation to a certain extent. This hindrance means that when elderly customers select channels, they care for more than just performance and the products purchased, the business processes, and the cost. Under normal circumstances, the higher the channel performance, the higher the cost. Therefore, excessive channel performance may not easily proliferate in most groups. Moreover, the elderly customer's

channel selection willingness will also be affected by multiple factors, such as individual customer characteristics, preferences, and perception capabilities. This paper considers the heterogeneity of individual behaviors based on the differences in individual elderly customers' social background, behavioral motivation, cognitive/perceptual capabilities, and individual preferences. A threshold model is presented for bank e-channel adoption in the small-world customer relationship network environment. This model can describe the process of individual elderly customer adoption to group adoption and the realization process of bank e-channel proliferation.

Second, in the small-world elderly customer relationship network, network scale and network density can adjust the influence of channel performance on the proliferation speed of banks' e-channels and the customer selection ratio. However, they need to be within the threshold range or under certain conditions to play a moderator role. Regarding the network scale, as the channel performance changes, the influence of the network scale on the bank's e-channel proliferation speed and elderly customer selection ratio is complex. For lower channel performance (from low to the relatively low-value range), the network scale plays a moderating role in the relationship between channel performance and bank's e-channel proliferation. In contrast, for higher channel performance range (relatively high to the high-value range), the network scale has a nonlinear effect on the proliferation speed and does not substantially influence the selection ratio. Regarding network density, under different channel performance levels, the proliferation speed and the customer selection ratio will exhibit a trend of first expanding and then shrinking as the network density changes, indicating that network density can adjust channel performance and proliferation effect. Nevertheless, when the network density increases by a particular value, this adjustment effect will gradually diminish until it disappears; in addition, the adjustment effect of the network density is also different in different ranges of channel performance. Specifically, in the range from relatively low to relatively high values, network density has the most apparent moderating effect in the relationship between channel performance, channel proliferation speed, and customer selection ratio. While in the range from low to relatively low or from relatively high to high, the network density has a limited moderating effect.

6.2 Implications

6.2.1 Theoretical Implications

This study has several theoretical implications. First, our study has enriched exiting literature on the elderly customer e-banking channel selection behavior. Existing literature mainly focuses on non-elderly customer selection behavior under the channel marketing environment (Rigby, 2011; Chopra, 2018; Park & Lee, 2017). However, customer decision-making differs among different customers. With the increasing financial demand of the elderly, it is also necessary to investigate the digitally enabled bank channel decision-making of the elderly. Therefore, this study pays more attention to the elderly and explores their e-banking channel selection behaviors. By analyzing the influencing factors of elderly customers' channel selection behavior and the decision-making process when choosing bank channels, this study defines the potential mechanism behind customers' channel selection intention in the environment of e-bank channels. Therefore, this study constructs a theoretical analysis framework based on complex networks, customer behavior economics, and cognitive psychology. It realizes the integration and development of relevant theories, which is of great significance to improving the theoretical system.

Second, this research has revealed the influence mechanism of elderly customer groups on e-banking channel selection behavior. In existing literature, Xue et al. (2007) analyzed the influencing factors of customers' individual channel selection behavior from a static perspective. Saghiri et al. (2017) explored the operation and management strategies of omni-channel banks based on customers' preferences. However, there is little literature on the channel selection behavior of bank customer groups from a dynamic perspective, especially research on the bank channel decision-making of elderly groups.

Third, this study has promoted the speed and depth of e-banking in the elderly in the context of Covid-19 pandemic. From the perspective of e-bank channels, this study provides a feasible solution to the problem of intelligent pension, promoting the habit of the elderly to use electronic channels and allowing the elderly to access the convenience and security of e-banking. This scheme provides mitigation measures for the 'intelligent disorder' of the elderly in the context of the epidemic, enhancing the elderly's sense of access, happiness, and security. At the same time, it helps alleviate the psychological and physical pressure brought by the epidemic to the elderly and assists them in medical care, which is of practical significance.

6.2.2 Practical Implications

This study also provides practical implications. First, regarding digital transformation, banks can comprehensively use technologic, systematic, service, and product innovations to create elderly-friendly e-banking services to optimize the channel performance and thus provide a more personalized operation and service experience. For example, banks should adopt measures to improve the use efficiency of e-channels, such as providing more humanized operation and service experience, improving the availability of e-financial services for elderly customers, customizing differentiated e-financial services for elderly customers.

Second, in the digital economy, banks should foster a strong corporate culture that emphasizes developing the network scale and network density of senior customers, such as setting up senior customer cultural organizations, building unique business culture, and fostering a culture in the banks for caring for elderly customers. In short, Chinese banks should firmly grasp the development trend of information technology and actively integrate financial science and technology transformation, innovation, and development. At the same time, Chinese banks should also undertake social responsibility, particularly providing financial services for elderly customers, and ultimately providing high-quality services for all kinds of customer groups under the background of bank channel transformation.

Third, our study provides prospective insights to deal with the damage caused by Covid-19. Deploying digitally enabled financial services is essential to revitalize the banking industry during the Covid-19 pandemic because of the restrictions on human movement. Moreover, banks have to shift their attention to digital transformation to prevent the spread of the Covid-19 virus and ensure the health of customers and staff. Our study provides practical value for banks to encourage their customers, particularly the elderly, to accept online services.

7. LIMITATION AND FUTURE WORK

This study uses a multi-agent simulation method to reveal the influence mechanism of e-banking channel selection behavior of elderly customers. This simulation research simulated the diffusion speed and depth of e-banking channels. In the process of channel selection of elderly customers, their behavior is complex in a changeable environment, and there are great difficulties in data acquisition and separation. Therefore, in the multi-agent simulation analysis, this study selects representative key and adjustment variables based on various literature and actual survey results. The initial parameter setting adopts the estimation method, which may have some deviation.

These results can be further improved in the follow-up research. While this study deeply analyzes the impact of channel performance, network structure, and other factors on channel selection behavior from the individual to the group level of elderly customers, the synergy of different factors and the complex relationship among them need to be further explored. In addition, we do not consider other influencing factors, but they can be added in the future to make this study more detailed.

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REFERENCES

Alalwan, A. A., Dwivedi, Y. K., Rana, N. P., & Algharabat, R. (2018). Examining factors influencing Jordanian customers' intentions and adoption of internet banking: Extending UTAUT2 with risk. *Journal of Retailing and Consumer Services*, *40*, 125–138. doi:10.1016/j.jretconser.2017.08.026

Bell, D. R., Gallino, S., & Moreno, A. (2018). Offline showrooms in omnichannel retail: Demand and operational benefits. *Management Science*, *64*(4), 1629–1651. doi:10.1287/mnsc.2016.2684

Borri, N., & di Giorgio, G. (2021). Systemic risk and the COVID challenge in the european banking sector. *Journal of Banking & Finance*, *106073*. Advance online publication. doi:10.1016/j.jbankfin.2021.106073

Campbell, D., & Frei, F. (2010). Cost structure, customer profitability, and retention implications of self-service distribution channels: Evidence from customer behavior in an online banking channel. *Management Science*, *56*(1), 4–24. doi:10.1287/mnsc.1090.1066

Chirisa, I., Mutambisi, T., Chivenge, M., Mabaso, E., Matamanda, A. R., & Ncube, R. (2020). The urban penalty of COVID-19 lockdowns across the globe: Manifestations and lessons for Anglophone sub-Saharan Africa. *GeoJournal*. Advance online publication. doi:10.1007/s10708-020-10281-6 PMID:32868960

Chopra, S. (2018). The Evolution of Omni-Channel Retailing and its Impact on Supply Chains. *Transportation Research Procedia*, *30*(9), 4–13. doi:10.1016/j.trpro.2018.09.002

Choudhury, V., & Karahanna, E. (2008). The Relative Advantage of Electronic Channels: A Multidimensional View. *Management Information Systems Quarterly*, *32*(1), 179–200. doi:10.2307/25148833

CSY. (2021). *China Statistical Yearbook*. China Statistical Publishing House.

Czajkowski, M., & Sobolewski, M. (2016). How much do switching costs and local network effects contribute to consumer lock-in in mobile telephony? *Telecommunications Policy*, *40*(9), 855–869. doi:10.1016/j.telpol.2015.10.001

de Reuver, M., Verschuur, E., Nikayin, F., Cerpa, N., & Bouwman, H. (2015). Collective action for mobile payment platforms: A case study on collaboration issues between banks and telecom operators. *Electronic Commerce Research and Applications*, *14*(5), 331–344. doi:10.1016/j.elerap.2014.08.004

Dempwolf, C. S., & Lyles, L. W. (2012). The uses of social network analysis in planning: A review of the literature. *Journal of Planning Literature*, *27*(1), 3–21. doi:10.1177/0885412211411092

Economides, N., & Jeziorski, P. (2017). Mobile money in Tanzania. *Marketing Science*, *36*(6), 815–837. doi:10.1287/mksc.2017.1027

Gerwe, O. (2021). The Covid-19 pandemic and the accommodation sharing sector: Effects and prospects for recovery. *Technological Forecasting and Social Change*, *167*, 120733. doi:10.1016/j.techfore.2021.120733

Gikandi, J. W., & Bloor, C. (2010). Adoption and effectiveness of electronic banking in Kenya. *Electronic Commerce Research and Applications*, *9*(4), 277–282. doi:10.1016/j.elerap.2009.12.003

Guido, G., Amatulli, C., & Sestino, A. (2020). Elderly consumers and financial choices: A systematic review. *Journal of Financial Services Marketing*, *25*(3), 76–85. doi:10.1057/s41264-020-00077-7

Hernando, I., & Nieto, M. J. (2007). Is the Internet delivery channel changing banks' performance? The case of Spanish banks. *Journal of Banking & Finance*, *31*(4), 1083–1099. doi:10.1016/j.jbankfin.2006.10.011

Hitt, L. M., & Frei, F. X. (2002). Do better customers utilize electronic distribution channels? The case of PC banking. *Management Science*, *48*(6), 732–748. doi:10.1287/mnsc.48.6.732.188

Huang, L. K. (2017). A cultural model of online banking adoption: Long-term orientation perspective. *Journal of Organizational and End User Computing*, *29*(1), 1–22. doi:10.4018/JOEUC.2017010101

Inegbedion, H., Inegbedion, E. E., Osifo, S. J., Eze, S. C., Ayeni, A., & Akintimehin, O. (2019). Exposure to and usage of e-banking channels: Implications for bank customers' awareness and attitude to e-banking in Nigeria. *Journal of Science and Technology Policy Management*, *11*(2), 133–148. doi:10.1108/JSTPM-02-2019-0024

Katz, M., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review*, *75*(3), 424–440.

Kaur, S. J., & Ali, L. (2021). Understanding bank employees' perception towards technology enabled banking: A developing country perspective. *Journal of Financial Services Marketing*, *26*(3), 129–143. doi:10.1057/s41264-021-00100-5

Kazancoglu, I., & Aydin, H. (2018). An investigation of consumers' purchase intentions towards omni-channel shopping: A qualitative exploratory study. *International Journal of Retail & Distribution Management*, *46*(10), 959–976. doi:10.1108/IJRDM-04-2018-0074

Khedmatgozar, H. R. (2021). The impact of perceived risks on internet banking adoption in Iran: A longitudinal survey. *Electronic Commerce Research*, *21*(1), 147–167. doi:10.1007/s10660-021-09475-y

Kiboori, C. K. (2017). *Electronic banking channels as a strategy for gaining competitive advantage in banking services: A case of Kenya Commercial Bank* [Master's Thesis]. United States International University - Africa. http://erepo.usiu.ac.ke:8080/xmlui/handle/11732/3393

Kumar, A., Mehra, A., & Kumar, S. (2019). Why do stores drive online sales? Evidence of underlying mechanisms from a multichannel retailer. *Information Systems Research*, *30*(1), 319–338. doi:10.1287/isre.2018.0814

Lee, H.-H., & Kim, J. (2010). Investigating dimensionality of multichannel retailer's cross-channel integration practices and effectiveness: Shopping orientation and loyalty intention. *Journal of Marketing Channels*, *17*(4), 281–312. doi:10.1080/1046669X.2010.512859

Liang, C.-C., & Nguyen, N. L. (2018). Marketing strategy of internet-banking service based on perceptions of service quality in Vietnam. *Electronic Commerce Research*, *18*(3), 629–646. doi:10.1007/s10660-017-9261-z

Lin, C.-C., Huang, W., Liu, W.-Y., & Wu, S.-F. (2019). A novel centrality-based method for visual analytics of small-world networks. *Journal of Visualization / the Visualization Society of Japan*, *22*(5), 973–990. doi:10.1007/s12650-019-00582-5

Malaquias, F., Malaquias, R., & Hwang, Y. (2018). Understanding the determinants of mobile banking adoption: A longitudinal study in Brazil. *Electronic Commerce Research and Applications*, *30*, 1–7. doi:10.1016/j.elerap.2018.05.002

Meresht, F. (2019). Providing a proper solution to solve problems related to banking operations through the atm machines to help the disabled, the elderly and the illiterate people: The selected papers of the first international conference on fundamental research in electrical engineering. *Lecture Notes in Electrical Engineering*, 897-912. doi:10.1007/978-981-10-8672-4_69

Modigliani, F., & Cao, S. L. (2004). The Chinese saving puzzle and the life-cycle hypothesis. *Journal of Economic Literature*, *42*(1), 145–170. doi:10.1257/002205104773558074

Msweli, N. T., & Mawela, T. (2020). Enablers and barriers for mobile commerce and banking services among the elderly in developing countries: A systematic review. *Responsible Design*. *Implementation and Use of Information and Communication Technology*, *12067*, 319–330. doi:10.1007/978-3-030-45002-1_27

Oesch, D., & Bachmann, K. (2009). Behavioural finance for private banking. *Financial Markets and Portfolio Management*, *23*(2), 205–206. doi:10.1007/s11408-009-0100-7

Oinas-Kukkonen, H., Hohtari, S., & Pekkola, S. (2010). Organizing end-user training: A case study of an e-bank and its elderly customers. *Journal of Organizational and End User Computing*, *22*(4), 95–112. doi:10.4018/joeuc.2010100105

Park, S., & Lee, D. (2017). An empirical study on consumer online shopping channel choice behavior in omni-channel environment. *Telematics and Informatics*, *34*(8), 1398–1407. doi:10.1016/j.tele.2017.06.003

Pauwels, K., & Neslin, S. A. (2015). Building with bricks and mortar: The revenue impact of opening physical stores in a multichannel environment. *Journal of Retailing*, *91*(2), 182–197. doi:10.1016/j.jretai.2015.02.001

Piazzi, R., Baggio, R., Neidhardt, J., & Werthner, H. (2011). Destinations and the web: A network analysis view. *Information Technology & Tourism*, *13*(3), 215–228. doi:10.3727/109830512X13283928066913

Qureshi, S. (2011). Information technology for development in expanding capabilities. *Information Technology for Development*, *17*(2), 91–94. doi:10.1080/02681102.2011.569355

Rigby, D. (2011). The future of shopping. *Harvard Business Review*, *89*(12), 65–76.

Rodríguez-Torrico, P., San José Cabezudo, R., & San-Martín, S. (2017). Tell me what they are like and I will tell you where they buy. An analysis of omnichannel consumer behavior. *Computers in Human Behavior*, *68*, 465–471. doi:10.1016/j.chb.2016.11.064

Rouhani, S., Ashrafi, A., Zareravasan, A., & Afshari, S. (2018). Business intelligence systems adoption model: An empirical investigation. *Journal of Organizational and End User Computing*, *30*(2), 43–70. doi:10.4018/JOEUC.2018040103

Schultz, E. E. (2000). Firms expand uses of retirement funds. *Wall Street Journal (Eastern Ed.)*, *235*(120), A2.

Sharma, R., Singh, G., & Sharma, S. (2020). Modelling internet banking adoption in Fiji: A developing country perspective. *International Journal of Information Management*, *53*, 102116. doi:10.1016/j.ijinfomgt.2020.102116

Shen, X.-L., Li, Y.-J., Sun, Y., & Wang, N. (2018). Channel integration quality, perceived fluency and omnichannel service usage: The moderating roles of internal and external usage experience. *Decision Support Systems*, *109*, 61–73. doi:10.1016/j.dss.2018.01.006

Sinnappan, G. S., Chua, K. Z., & Ong, B. C. (2022). E-banking services acceptance in Malaysia. In P. C. Lai (Ed.), *Handbook of Research on Social Impacts of E-Payment and Blockchain Technology* (pp. 342–361). IGI Global., doi:10.4018/978-1-7998-9035-5.ch018

Sundararajan, A. (2005). *Local Network Effects and Network Structure*. New York Univesity.

Takieddine, S., & Sun, J. (2015). Internet banking diffusion: A country–level analysis. *Electronic Commerce Research and Applications*, *14*(5), 361–371. doi:10.1016/j.elerap.2015.06.001

Tam, C., & Oliveira, T. (2019). Does culture influence m-banking use and individual performance? *Information & Management*, *56*(3), 356–363. doi:10.1016/j.im.2018.07.009

Verhoef, P. C., Kannan, P. K., & Inman, J. J. (2015). From multi-channel retailing to omni-channel retailing: Introduction to the special issue on multi-channel retailing. *Journal of Retailing*, *91*(2), 174–181. doi:10.1016/j.jretai.2015.02.005

Wang, K., & Goldfarb, A. (2017). Can offline stores drive online sales? *JMR, Journal of Marketing Research*, *54*(5), 706–719. doi:10.1509/jmr.14.0518

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world' networks. *Nature*, *393*(6684), 440–442. doi:10.1038/30918 PMID:9623998

Xu, X., & Jackson, J. E. (2019). Examining customer channel selection intention in the omni-channel retail environment. *International Journal of Production Economics*, *208*, 434–445. doi:10.1016/j.ijpe.2018.12.009

Xue, M., Hitt, L. M., & Chen, P. (2011). Determinants and outcomes of internet banking adoption. *Management Science*, *57*(2), 291–307. doi:10.1287/mnsc.1100.1187

Xue, M., Hitt, L. M., & Harker, P. T. (2007). Customer efficiency, channel usage, and firm performance in retail banking. *Manufacturing & Service Operations Management*, *9*(4), 535–558. doi:10.1287/msom.1060.0135

Yeung, W. C., Liu, W., & Dicken, P. (2006). Transnational corporations and network effects of a local manufacturing cluster in mobile telecommunications equipment in China. *World Development*, *34*(3), 520–540. doi:10.1016/j.worlddev.2005.07.019

Zarifis, A. (2019). The six relative advantages in multichannel retail for three-dimensional virtual worlds and two-dimensional websites. *Proceedings of the 10th ACM Conference on Web Science*, 363-372. doi:10.1145/3292522.3326038

Zarifis, A., & Kokkinaki, A. (2015). The relative advantage of collaborative virtual environments and two-dimensional websites in multichannel retail. In Lecture Notes in Business Information Processing (Vol. 208, pp. 233-244). doi:10.1007/978-3-319-19027-3_19