

Méndez Suárez, Mariano; Danvila del Valle, Ignacio; González-Tejero, Cristina Blanco; Gavrila Gavrila, Sorin

## Article

# Negative word of mouth (NWOM) using compartmental epidemiological models in banking digital transformation

Contemporary Economics

## Provided in Cooperation with:

University of Finance and Management, Warsaw

*Suggested Citation:* Méndez Suárez, Mariano; Danvila del Valle, Ignacio; González-Tejero, Cristina Blanco; Gavrila Gavrila, Sorin (2023) : Negative word of mouth (NWOM) using compartmental epidemiological models in banking digital transformation, Contemporary Economics, ISSN 2300-8814, University of Finance and Management in Warsaw, Faculty of Management and Finance, Warsaw, Vol. 17, Iss. 1, pp. 77-91,  
<https://doi.org/10.5709/ce.1897-9254.500>

This Version is available at:

<https://hdl.handle.net/10419/297622>

## Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

## Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by/4.0/>

Primary submission: 15.06.2022 | Final acceptance: 27.12.2023

# Negative Word of Mouth (NWOM) using Compartmental Epidemiological Models in Banking Digital Transformation

Mariano Méndez-Suárez<sup>1,2</sup> and Ignacio Danvila-del-Valle<sup>3</sup>

Guest editors: Cristina Blanco González-Tejero<sup>4</sup> and Sorin Gavrila<sup>4</sup>

## ABSTRACT

Our article is among the first to model the reactions of customers to the digital transformation of European banks in a scenario of declining interest margins. Motivated by the hypothesis that customers' feelings, perceptions and negative reactions towards digital transformation are channeled through the spread of negative word-of-mouth (NWOM) in a way analogous to the spread of a disease epidemic, we propose and analyze a compartmentalized mathematical model using data from a medium-sized Spanish commercial bank. To understand the NWOM phenomenon with an epidemiological approach we consider some realistic interactions in a social network and we formulate a novel application of the susceptible-exposed-infected-recovered-mortality (SEIRM) model. The results indicate that a better understanding of consumers' negative reactions and their correct monitoring can help banks improve profitability when facing a digital transformation process. In summary, the research warns commercial bank managers about the need to carefully assess the effects of changes brought about by digital transformation and the development fee management strategies based on the behavior of customer groups, as well as the deployment of new churn risk management methods to deal with the most disengaged customers.

## KEY WORDS:

NWOM, negative word of mouth, epidemiological models, banking, digital transformation.

**JEL Classification:** L22, M30.

<sup>1</sup>ESIC University, Pozuelo de Alarcón (Madrid), Spain

<sup>2</sup>ESIC Business & Marketing School, Pozuelo de Alarcón (Madrid), Spain

<sup>3</sup>Complutense University of Madrid, Spain

<sup>4</sup>Economics and Business Management Department, University of Alcalá, Madrid, Spain

## 1. Introduction

Current digital transformation of the banking industry will yield potentially higher competitiveness and profitability (e.g. Porter & Heppelmann, 2014, 2015). Digital transformation defined as the use of digital technologies in the pursuit of a more efficient creation of value (Horváth & Szabó, 2019) is changing the way banks interact with their customers in the pursuit of private and social efficiency gains (Carbó-Valverde et al., 2020), but is also having undesirable consequences

for some customers who have noticed a lower level of service, which is generating negative perceptions, such as the erosion of the sense of community and family (Schwab, 2017), the loss of traditions and values (Boogaard et al., 2011) or the destruction of many jobs (Rampersad, 2020).

At the same time, the negative interest rates of recent years in Europe, ranging from  $-0.10\%$  in 2014 to  $-0.50\%$  from 2019 (European Central Bank, 2022) are reducing the interest spread of commercial banks to a minimum, increasing the already large proportion of

Correspondence concerning this article should be addressed to:

Mariano Méndez-Suárez, Av. de Valdenigrales, s/n, 28223

Pozuelo de Alarcón, Madrid, Spain. E-mail: [mariano.mendez@esic.university](mailto:mariano.mendez@esic.university)

unprofitable banking customers (Méndez-Suárez & Crespo-Tejero, 2021). To face this situation, commercial banks increase pressure on customers, who did not need or want it, to purchase additional products, such as life insurance, and subscribe to new services in the bank's portfolio (Canlas, 2019) as the only way to maintain low levels of fees and expenses.

Although financial institutions promote digital development, consumers have lost confidence in banks (Costa-Climent & Martínez-Climent, 2018) because the data-driven business models organized by the criterion of expected value generated for the customer (Wiśniewski et al., 2021) may result for some customers in a lower level of service due to the reduction of the structure's cost, and a more impersonal relation that may cause consumers to form weaker connections creating pseudo-relations with an increase of the levels of disengagement (Bowden et al., 2015) and dissatisfaction from their bank (Kumar & Mehrotra, 2022) triggering the desire to terminate the relationship, as they feel abandoned because their numbers show they are no longer profitable (Lamrhari et al., 2022). This pursuit of the bank's profitability was seen as indirect termination by a number of customers that perceived it as unfair because these actions are inconsistent with how a company is supposed to treat its customers (Lepthien et al., 2017). Therefore, these negative emotions of bank customers resulted in anger reactions, involving consumer retaliatory behaviors for perceived injustice (Huefner & Hunt, 2000), generating negative-word-of-mouth in social networks (NWOM hereafter); disengaged customers also contributed to the spread of NWOM (Dalzotto et al., 2016; Haenlein & Kaplan, 2012; Jabeen et al., 2022).

This NWOM caused from angry and disengaged customers moves freely with the interaction between many members through the Internet, making NWOM on social media an infection similar to those of an epidemic, since the spread of information is so rapid that it can easily be compared to an outbreak of the infection (Anand et al., 2021; Bhattacharya et al., 2019). Back in 1964, Goffman and Newill (1964) considered the transmission of ideas within a population as an epidemic process in which the exposure to some phenomenon (infectious material) starts the transition from one compartment (susceptible, S) to another (exposed, E) that may become (infective, I)

to finish in two possible fourth compartments (recovered, R) or (mortality, M). This process is known as the susceptible-exposed-infected-recovered-mortality (SEIRM) epidemiological model and is illustrated using differential equations. SEIRM epidemic models are appropriate for modeling the transmission of information of NWOM through social networks by angry and disengaged customers due to their parallels with the spread of disease in biological networks (Kandhway & Kuri, 2014).

Within the digitalization and Industry 4.0 literature (e.g. Horváth & Szabó, 2019; Porter & Heppelmann, 2015) along with the consumer behavior literature (e.g. Akdim, 2021; Kumar & Mehrotra, 2022) we follow that unresolved tension to study consumers' negative reactions to digitally-intensive innovative financial services. Given the described context, the main objective that guide this work is to contribute to the better understanding of the behavior of angry bank customers who express through the NWOM their reactions and intention to churning intend, in the face of increased fees and reduced banking service quality. Overall, this study aims to contribute to the literature by answering the following question: can the churning behavior of disengaged customers, expressed through the NWOM, be better understood modeling it with a compartmental epidemiological model?

To answer this question, we develop and apply a SEIRM epidemic model to dynamically analyze the behavior of the different compartments of customers from a medium-size Spanish bank; our model expands significantly from the baseline SIR epidemic models for information diffusion.

To summarize our results, commercial bank managers need to carefully assess the effects of changes brought about by digital transformation and fee management according to customer groups and develop new methods of churn risk management to deal with disengaged groups of customers.

This article is organized as follows. The section "Theoretical framework" summarizes previous research on customer divestment, NWOM and information diffusion in social networks and then presents the SEIRM model. The data and model are reported in the "Data and methods" section continuing with a "Results" section. The research conclusions and future directions are presented in the section "Summary and discussion".

## 2. Theoretical Framework

### 2.1. Customer Response to Divesting Strategies

When margins decrease, companies nudge unprofitable customers into more lucrative accounts, charging them higher fees or pressing them into buying additional products and services (Sanders, 2000); in most cases, only profitability considerations lead service providers to service contract demotion (Haenlein & Kaplan, 2011). These initiatives to increase prices and reduce the levels of service by sending the customers to automated procedures created via digital algorithms imply a customer perception that the company is not giving an appropriate customer care and makes a negative impact on the perception of service quality, decreasing the levels of satisfaction of customers (Nijssen et al., 2016). In addition, this attitude may cause severe reactions of customers including full reconsideration of the business relationship and can generate high levels of betrayal (Nazifi et al., 2021). In this sense, and specifically in the banking industry, a survey of over 1,700 consumers (Caporal, 2023) found that the most important features consumers want from a bank are high-quality customer service and low fees. And more importantly: If consumers could only have one feature in a bank, it would be low fees.

Customers experiencing divesting strategies, as those related with increase in fees and decrease in service by automation, generate NWOM and show negative attitudinal responses as well as those merely observing these business policies (Lepthien et al., 2017). In this sense, the desire for revenge generates a higher volume of NWOM (Grégoire et al., 2009) that may increase the desire to churn, although some customers can make a silent churn because current work shows that consumers are sometimes reticent to share such NWOM because they believe it could cause them to appear incompetent (Philp & Ashworth, 2020). Additionally to the NWOM of the current customers there is also the impact of customers who report their disappointment about their previous service provider to others in the form of NWOM (Wangenheim, 2005).

According to the theory of social sharing of emotions (Rimé, 2009), individuals present a natural disposition to share emotional experiences with other individuals. Currently, social media are used as channels of discussion by millions of people every day,

encouraging the belief that WOM is more trustworthy and believable because sharing product information by WOM is not motivated by financial gain, having special impact in segments with strong affinity (Mora et al., 2021). Additionally, previous research found that individuals are often influenced by others with whom they have tenuous or even random relationships (Goldenberg et al., 2001). In the case of anger or disengaged customers, NWOM communications in general may involve discrediting the product or service to make an unfavorable impact and attitudes towards the company (Liu, 2006). In this vein, it is well-documented that NWOM has effects of larger size than its positive counterpart (Babutsidze, 2018); also that NWOM of churned customers increases churn rates of current customers (Wangenheim, 2005).

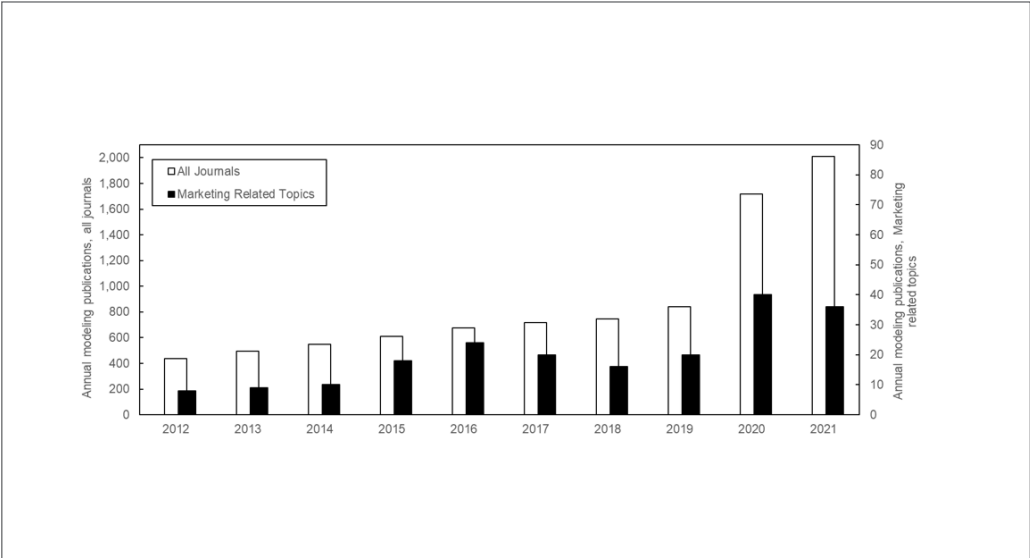
Regarding the decay effect of disengagement and anger, some authors note that the desire for revenge decreases over time, given the difficulty of sustaining revenge over the long term (Grégoire et al., 2009).

### 2.2. SIR Compartmental Epidemiological Models

In recent years, there has been a growing trend in the publication of epidemiological models in journals in areas such as mathematics and physics, as well as in other leading technical journals (e.g., Ghosh et al., 2020; Li et al., 2018; Woo et al., 2015). In addition, epidemiological modeling for the study of marketing related applications is generating a considerable interest. Figure 1 shows the evolution of articles published in modeling journals using epidemiological models and articles published using this type of model with specific marketing applications.

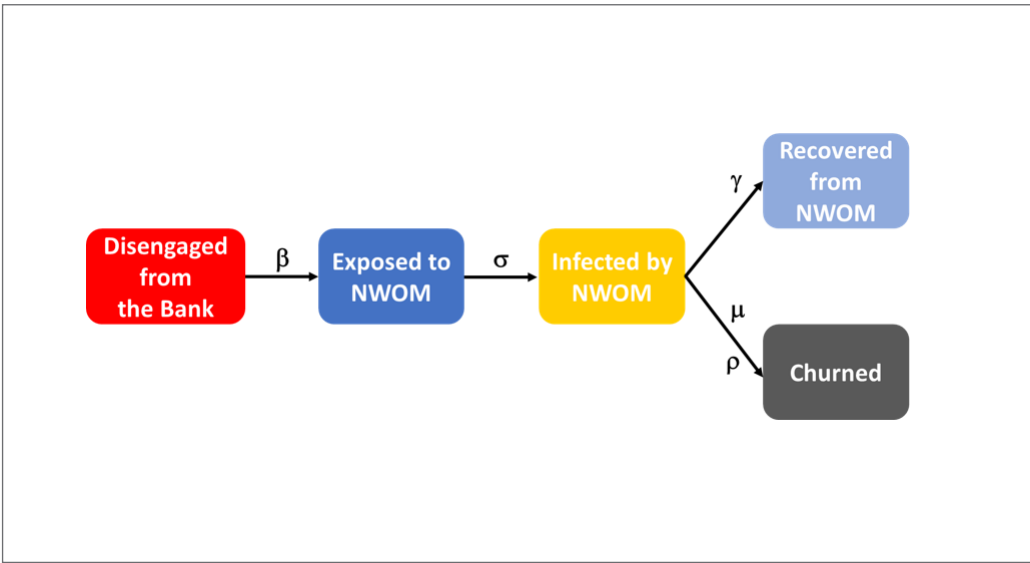
The SIR family of compartmental models offers a rich range of possibilities for applying its theoretical approaches to the multiple aspects of information diffusion required by managers in the development of their strategies. Goffman and Newill (1964) used SIR epidemic models to better understand the spread of scientific ideas, comparing them to a disease diffusion. More recently epidemic models have been used to analyze a wide array of phenomena related to the viral expansion of ideas, many of them specifically applied to deal with marketing problems. Woo et al. (2015) applied epidemiological models to model the dynamics of medical information through web forums in medical industry. Research from Woo and Chen (2016) used

**Figure 1**  
*An Indication of the Increasing Importance and use of Mathematical Models in the Epidemiological Literature*



Note: White bars (left axis) show the approximate number of publications in the entire scientific literature that utilize models of infectious diseases (Data obtained from the Web of Science and include publications that respond to the following query contained in their title or abstract: epidemic AND "infect\*" AND ("model\*" OR "simulat\*") AND "marketing"). The black bars (right axis) show the number of these publications containing marketing-related topics (Data obtained from the Web of Science and include publications that responds to the following query contained in their title or abstract: "epidemic" AND "infect\*" AND ("model\*" OR "simulat\*") AND ("WOM" OR "Word of mouth" OR "marketing" OR "social networks" OR "social media")

**Figure 2**  
*Flow of “Infectious” NWOM Across the Disengaged Customer Base*



epidemiological models to better understand the diffusion of information among social media and web forums in political dialog. Jiang et al. (2017) used a diffusion model to forecast market performance of new products. Regarding WOM marketing, Li et al. (2018) developed a theoretical mathematical structure of the WOM marketing, by transforming the susceptible-infected-susceptible (SIS) model. Ghosh et al. (2020) used a diffusion model to analyze the spread of referral marketing campaigns. Sharma (2021) applied a compartmental model to study the role of information in the spread of experiences in online shopping. The article by Wood (2021) SIR modeled the impact of PWOM and NWOM in a not for profit marketing using a SIR model based on a Bass model.

The present research uses the SEIRM model (Anand et al., 2021), which is an extension of the SIR model, to understand the process of how disengaged and angry customers from a bank churn or decide to stay with their current bank. The model includes two additional compartments to the traditional SIR model and is depicted in Figure 2.

Where the first compartment is Susceptible, or in our case customers “Disengaged from the Bank”, corresponding to customers who decrease their linkage-business with the bank as well as their engagement and are more prone to enter in the second compartment or have been Exposed to the infection of the bad comments about the bank or “Exposed to NWOM”, some of them will be infected by the virus of the negative comments or “Infected by NWOM” and finally can move either to the Recovered state or “Recovered from NWOM” accepting the new situation, or to Die by the infection by entering in the “Churned” compartment.

The flow of customers between compartments is characterized by the following parameters:

$\beta$ , beta is the transmission coefficient of the NWOM or the average number of infectious contacts or NWOM interactions a customer may have. The higher the value of  $\beta$  the higher the level of propagation.

$\sigma$ , sigma is the rate at which exposed individuals become infectious. Or the reciprocal of the average time it takes to become infectious by NWOM about the bank.

$\gamma$ , gamma is the rate at which infectious individuals recover or the reciprocal of the average time it takes

to recover.

$\mu$ , mu describes the mortality rate or the churn rate of the bank customers. The higher the  $\mu$  the higher the number of customers that churn.

$\rho$ , rho represents the time it takes to die once infected or the time it takes to make the decision to churn.

Next, we illustrate the model with the evolution of the customers of the bank for the different stages until recovery or churn.

A limitation of the SIR family models is that assumes an homogeneous mixing of infected and susceptible populations and that the total population is constant over time, which can be unrealistic in some cases (Cooper et al., 2020).

### 3. Data and Methods

#### 3.1. Data

The data was provided by a medium-size Spanish commercial bank focused on traditional retail banking products and services; the name of the bank is not disclosed as they preferred to maintain confidentiality. To ensure the confidentiality of these data we multiplied all monetary values by an arbitrary factor, which we choose to be small enough so as not to distort the data patterns. Therefore, they are no longer expressed in euros, but in monetary units. The dataset contains anonymized retail customer information and includes each household's 2018 and 2019 gross margin (GM). GM includes income from interest and service fee payments, less liquidity, equity, risk and transaction costs. These costs serve to remunerate the bank's cost of holding cash, maintaining a certain equity ratio dependent on credit risk, accepting the risk of credit loss and carrying out customer-related transactions respectively. The bank measures customer engagement-linkage based on year-over-year GM increase. Of the total customer base, 779 thousand customers increased GM, which the bank assumes is an increase in engagement. Customers who decreased GM or disengaged from the bank were 676 thousand and lastly, a total of 103 thousand customers churned. A summary of the information at year end of 2018 is in Table 1.

#### 3.2. Methods, Modeling NWOM as an SEIRM Infection Process

In the present model, disease infection spreads through social networks contact; it starts when a fraction

**Table 1**  
*Disaggregation of the Customer Base at Year-end 2018*

Year end	2018
Engaged, increased GM	779,433
Disengaged, decreased GM	676,638
Churned	103,274
Total	1,559,345

of people who are the first users to engage in NWOM take the role of a long fuse (Jiang et al., 2017) that triggers the customers disengaged or anger with the bank and may be considered the patient zero of the infection. Each infected person then has contact with others through the network and individuals that had contact with infected people become infected themselves at a certain rate (Woo & Chen, 2016). The infected process continues until no more susceptible or disengaged customers exist. The different compartments of the SEIRM model and their equivalents in the marketing terminology that we applied are explained in Table 2.

Next, we define the customers that populate the different compartments, starting with Immune; this group of customers corresponding to the 779,433 engaged customers that increased their business with the bank may be considered immune to NWOM comments and furthermore may be posting positive-word-of-mouth (PWOM) comments on social networks. This is shown by the following verbatim comments obtained from the website

<https://www.helpmycash.com/> from the year 2018, Table 3, which highlight generally positive aspects of the bank, but also the fact that if the level of linkage is very high, no fees are paid and that both the mobile app and the website are very good.

This kind of customer coincides with previous research highlighting that individuals who feel a close personal connection to the brand are usually the best customers (Wilson et al., 2017) and that such consumers process NWOM defensively and even increase their engagement with the brand. These customers are not included in the dynamical model.

The next group corresponds to susceptible customers, that is the 676,638 customers who decreased their level of business with the bank. This group will be used as the population for the model. This group of customers may be Exposed to NWOM, Infected by its comments together with their own anger and disappointment and be Recovered or directly Mortality abandoning the bank.

**Table 2**  
*Compartments in the SEIRM Model and their Equivalents in the NWOM Diffusion model of the Spread of NWOM and Customers' Churn*

SEIRM model	Epidemics	NWOM Diffusion
Immune (In)	People with natural immunity to the disease.	Engaged customers who increased their business with the bank, immune to NWOM
Susceptible (S)	People who can become infected.	Disengaged customers who decreased their business with the bank
Exposed (E)	People exposed to the infection, infected but not infectious.	Disengaged customers who are exposed to NWOM
Infected (I)	People infected and who act as an infectious agent.	Disengaged customers infected by and transmitting NWOM
Recovered (R)	People who recovered from the infection and acquired immunity.	Infected customers who stop transmitting NWOM and continue as customers.
Mortality (M)	The people who died because of the disease.	Customers who abandoned the bank

This group of customers corresponds to the NWOM comments found on the website <https://www.helpmycash.com/> from the year 2018 in Table 4. Although Table 4 contains only 23 comments, they were numerous on the website. As expected, the comments were related to the increase of fees and charges and the decrease of quality of the customer service by digital transformation. Some of the customers even stated their intention to abandon.

The Recovered compartment contains a total of 573,364 customers corresponding to the disengaged customers minus the churners (676,638–103,274).

The propagation of the NWOM network is modelled on a discrete time basis with the propagation occurring simultaneously at each time instant (Bampo et al., 2008) with the SEIRM model based on the building of the following system of differential equations used to model the spread of disease under the above conditions, and the system is solved using the R library deSolve (Soetaert et al.,

2010) using as initial conditions  $S = 676,638$ ;  $E = 100$ ;  $I = R = M = 0$ :

$$\frac{dS}{dt} = -\frac{\beta SI}{N} \quad (1a)$$

$$\frac{dE}{dt} = \frac{\beta SI}{N} - \sigma E \quad (1b)$$

$$\frac{dI}{dt} = \sigma E - (1 - \mu)\gamma I - \rho\mu I \quad (1c)$$

$$\frac{dR}{dt} = (1 - \mu)\gamma I \quad (1d)$$

$$\frac{dM}{dt} = \rho\mu I \quad (1e)$$

In Eq. (1a) to (1e),  $S, E, I, R, M$ , are individuals in the five states: susceptible, exposed, infective, recovered or dead. In addition,  $N$  represents the total number of individuals at time  $t$ , namely,  $N = S + E + I + R + M$ ;  $\beta$  is the transmission coefficient of NWOM;  $\sigma$  is the rate of infections by NWOM;  $\gamma$  gamma is the rate of recovery of infected by NWOM;  $\mu$  the mortality or churn rate; and  $\rho$  the time it takes to die or to churn.

**Table 3**

*The Verbatim from a Total of 10 PWOM Comments from the Customers in the Years 2018 and 2019*

Reason	PWOM Comment
g	The best bank
g	Excellent management and solvent bank.
g	Good entity. Recommendable.
g	Happy with ****
g	Excellent entity. Close and with good products.
v	They have been updated quite a lot. Good entity. No commissions are paid as long as you link with them.
v	Good products. Very low commissions for payroll, savings and others. I don't pay for anything.
v, w	I recommend this bank. No fees and commissions for linking. Free card. I don't usually go to the office. much. I do everything from their app or internet. very convenient.
v, w	I have a mortgage, savings and insurance with them. I don't pay for anything. Good online banking.
v, w	Good app and web. Very convenient to do everything without having to go to offices.

Source: Selected for illustrative purposes from a site specialized in financial services: <https://www.helpmycash.com/>; The number of comments is approximately proportional to the number of comments expressing NWOM in Table 4. Translation from Spanish done by the authors.

Note: The comments have been classified according to the three reasons for recommendation found: where g, indicates a general positive comment on the bank; v, indicates positive comments on low fees with high number of products or services contracted; v, w indicates positive comments on low fees with high linkage and the quality of digital banking.



**Table 4**  
*The Verbatim Comments from a Total of 23 NWOM Comments from the Customers in the Years 2018 and 2019*

Reason	NWOM Comment
f	Lately they have become ****, charging new commissions without warning, even for their accounting notes. The clerks have also become rude as a result of having to put up with angry customers because of these changes.
f	They charge you fees for breathing. Every day I look at my account I have a new fee counted and it takes weeks to try to get it back. If you get it back at all.
f	They even charge for breathing, for transfers between accounts of the same account holders, etc.
f	All my life with them. and **** charging commissions and everything else. next month I'm leaving. maybe they will even charge me for leaving .....
f	No matter how much you link you continue charging commissions. It is difficult for me to escape without getting caught. I will have to withdraw my money in cash.
f	They are ****, I took away my salary and now they charge me for breathing (and I am paying them a mortgage and the insurance for the apartment). They charge me 80 cents for each payment that someone sends me, 50 euros for account maintenance, a lot of money for each transfer I make (and they don't charge me more because I cancelled all the other services).
f	If you want a bank that charges you for everything, this is your bank. Little more to say. I do not recommend *** at all; there are other much "cooler" entities without any kind of commission.
f, s	They are very good at charging for everything and very bad in front of the customer.
f, s	It is a shame since it is no longer a savings bank, having savings insurance, funds...payroll, money in the account, they charge me fees for everything: the debit card, for making transfers, for account maintenance...in the end I just canceled it and I have changed, and on top of that I tried to contact my manager and she did not even answer me a week ago.
f, s	I think they are ****, they take advantage of the fact that there are many elderly people to charge them fees for everything and provide them with products that only benefit **** itself, without caring about the customer.
f, s	I am a customer of this lousy entity, by absorption of my old savings bank. I have never, and I repeat never, met such unrepresentable people in a bank. I have worked with several offices and all with a clumsy management and over expensive fees for doing things wrong.
f, s	They are always understaffed, it takes forever to do anything. And on top of that they charge commission for everything. I do not recommend it.
f, s, c	In my branch nothing works, neither the ATM nor the one to update the passbook or anything else, so every time the ATM fails, I have to go to another one 10km away from my house or withdraw from another entity and I get charged. In short, I am not very happy. When I can, I will go to another bank.
s	Shameful about this bank, they charge for everything, very bad customer service.
s	The customer service is lousy. To receive information you have to be on the phone for a long time. In the end I received the information I wanted through a company I found on the internet.
s	It seems to me that the bank does not facilitate anything to their clients. It seems that they don't want to provide solutions, let alone make them. They bounce everything back to the client to do all their work for them.
s	Ahhh, they should give their employees a good course in customer service, education, respect and tact, and teach them the following: Treat your customers as you want them to treat you.
s	It's the worst, as soon as I can I change all my income and close my account, bad service, I do not recommend it.
s	Their Online Banking .... better not to enter ... difficult to navigate and no flexibility when it comes to making arrangements, which by the way they charge you the same.

**Table 4***The Verbatim Comments from a Total of 23 NWOM Comments from the Customers in the Years 2018 and 2019 (Continued)*

Reason	NWOM Comment
s	Lousy personal treatment. In the branch in ****, the branch manager was rude, shouting over the phone, a disgrace. They charge for absolutely everything. I do not recommend it.
s	THEY DON'T CARE IF YOU ARE A LONG TIME CUSTOMER.
c	I am looking forward to finish paying the mortgage to change banks. They don't make things easy and they charge for everything.
c	The worst bank I have ever worked with, I have cancelled my mortgage in advance and closed my account, I do not recommend it.

Source: Selected for illustrative purposes from a site specialized in financial services: <https://www.helpmycash.com/>; The number of comments is approximately proportional to the number of comments expressing PWOM in Table 3. Translation from Spanish done by the authors.

Note: Comments have been classified according to the three complaint reasons found: where f, indicates negative comments on commissions; s, indicates negative comments on service; c, indicates intention to churn. In some cases, complaints refer to more than one reason, e.g., f, s, means commissions and service.

**Table 5***Coefficients Used to Solve the System of Differential Equations*

Coefficient	Value
$\beta$	1/2
$\sigma$	1/50
$\gamma$	1/14
$\mu$	1/3

To model the evolution of the rate of infections, we use the estimation of Luo (2009) for the spread of NWOM. As for the remaining coefficients of the differential equations, because of lack of previous literature on the coefficients needed to solve the system of differential equations, we developed the hypotheses in Table 5.

The R code used for to solve the differential equations and the creation of the model shown in the next section is available from Harvard Dataverse (Méndez-Suárez & Danvila del Valle, 2023).

## 4. Results

The model attempts to replicate the behavior of disengaged bank customers over the course of 2018. The assumptions from the selected coefficients are the following: The coefficient  $\beta$  assumes that on

average each individual infects 0.5 individuals, or one individual every two days. The time to become infectious, based on  $\sigma$  is 50 days as per previous estimations on the spread of NWOM (Luo, 2009), implying that the peak of the exposition to NWOM occurs at 4.2 months, while the depletion effect (the period of time between the impact of the peak until the impact of the NWOM disappears completely) occurs at 6.7 months. The coefficient  $\gamma$  implies that the average time to recover is 14 days. The coefficient  $\mu$  implies that one third of the infected customers will churn and that they need the inverse of  $\rho$ , or 35 days to make the decision. The paths of the ODE solution are depicted in Figure 3.

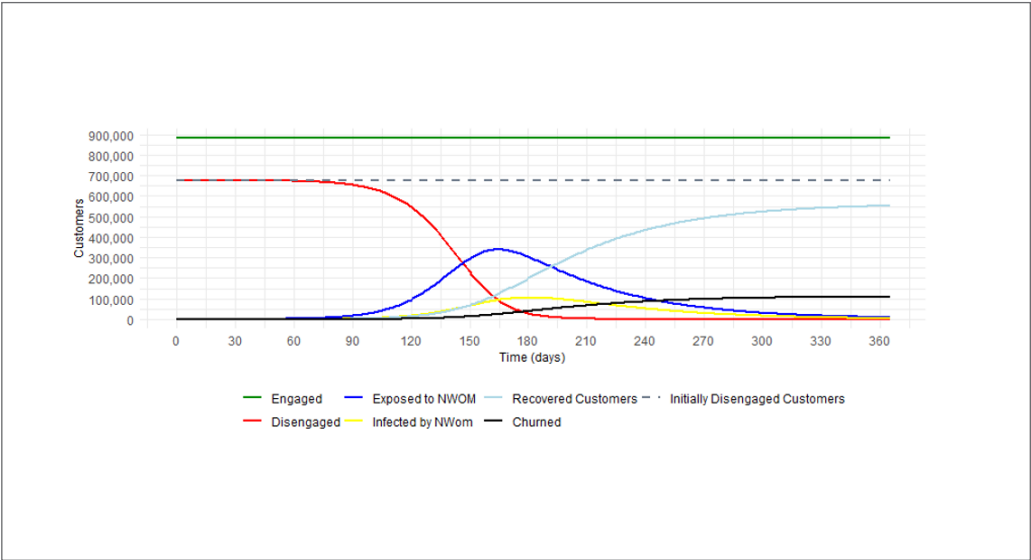
From Figure 3 we see that the compartment representing disengaged customers decreases after the first 90 days, then these customers move relatively

quickly to the next compartment, which corresponds to customers who have had some kind of exposure to NWOM, either related to service quality, increased fees or direct feedback from customers leaving the bank, at this point the bank managers should act and start treating those infected customers who are expressing to the bank their dissatisfaction with the new situation, trying to give them a solution, either cheaper by lowering the level of service and at the same time improve the usability of the new technologies introduced for the relationship with the customers, at the meantime the bank aware of the situation can contact the other disconnected customers to try to vaccinate them again from the highly dangerous situation in which the bank finds itself. The peak of this exposure curve occurs around day 170, after which this curve begins to decline progressively.

At the same time, the curves corresponding to the other three compartments are in motion. If we next look at the curve corresponding to the Infected by NWOM customers, i.e., those for whom abandonment is already becoming a clear possibility and who may contribute with their experiences to the spread of the infection, this curve reaches its peak shortly after that of the Exposed customers, and from that point it decreases very slowly until the end of the year.

The next curve we analyze is the one corresponding to Recovered customers, who could have decided to stay, either because a renegotiation of terms with the bank or after the analysis of the switching costs; in this sense, the cost involved in finding a new service provider and its geographic proximity have significant influence on the customer decision

**Figure 3**  
*Paths of the ODE Solution for the Modeling of the Behavior of Disengaged Customers Over the Course of 2018*



Note: Engaged customers are constant because they are assumed to be immune; Disengaged corresponds to susceptible customers to the infection of NWOM; Exposed are the customers exposed to the infection of NWOM; Infected by NWOM are customers that move to the next compartment, either as Recovered customers who decide continue relation with the bank, or as Churned, or “dead” customers who definitively broke relations with the bank.

to continue with the bank (Lee & Cunningham, 2001). Not all these customers are loyal because of engagement but do not want to go through the inconvenience of switching convenience of location and they will probably churn if they find a better alternative (Lee & Cunningham, 2001).

The remaining compartment corresponds to customers who defected and starts to increase just at the point where the peak of the curve of exposed customers is reached, and from there it rises smoothly but relentlessly until it arrives at the number of the 103 thousand customers who defected. Those customers who have a very high risk of churning, or dying according to the model, should be analyzed to see if it is really worth trying to keep them or if it is a better solution to let them go (Méndez-Suárez & Crespo-Tejero, 2021).

## 5. Summary and Discussion

This study's aim focuses on understanding the process behind the churn behavior of customers subject to the pressure of banking digital transformation and increase in fees and charges. We have adapted the SIR epidemics model proposing a novel application that can be used to understand the churning behavior of customers. The model is based on a compartmental model of the SIR family, but includes two additional compartments to represent the exposure (E) to infection of disengaged customers caused by NWOM and a compartment representing the churn behavior, or "mortality" (M), of disappointed customers, becoming a SEIRM model.

The proposed SEIRM model helps to understand better the reality behind customers with high levels of disengagement and anger with banks after a digital transformation process, providing excellent marketing levers for aggregate control of customer evolution management through the study of the different parameters that condition each of the compartments, including infection rates, infection recovery times or attrition rates. Models have two distinct roles: prediction and understanding (Keeling & Rohani, 2011), in this sense, we consider that the present research is a first step to improve the understanding of the reactions of disengaged customers to digital transformation.

Furthermore, for the digital transformation process to be a success, should be understood as involving a process of management change (Montero Guerra et al., 2023) that must be properly explained to the parties involved and especially to customers, since otherwise this change can have a negative impact on the image that customers have of the company and generate an infectious process of negative opinions, especially dangerous through the NWOM. Therefore, companies must ensure that the changes brought about by digital transformation are understood by all the people involved and directly affected by them, especially customers. The potential benefits of digital transformation may include increased sales, productivity, innovations in value creation, or new ways of interacting with customers (Berman, 2012), but on this last point, care must always be taken to ensure that the customer understands that the changes are intended to improve the services provided to them. In short, digital transformation involves more than just incorporating technology into business processes; it is a profound change in the organization, from strategy to technology, including changes in the value chain, culture, processes, human resources, and specially customer relationships (Pertusa-Ortega et al., 2010; Smith & Reece, 1999).

### 5.1. Academic and Managerial Implications

This study has an important academic implication, as is the first to combine the concept of viral marketing, which has been widely studied in the marketing literature (i.e., Jansen, 2019) with the most advanced infections research models (i.e., Rodrigues, 2016). Its results, in addition to broadening the academic field of study through the combined consideration of these two phenomena, also allow to develop the study of NWOM management when it comes to customer transfers from an engagement compartment to a compartment infected by negative viral marketing.

A key implication for managers is that this research confirms that the changes brought about by digital transformation can have a negative impact on customers' perceptions of banks. Especially in a scenario of seeking profitability by increasing fees or forcing customers to buy more financial prod-

ucts. This context makes customers much more susceptible to the possible infection (i.e., infection compartment) created by NWOM, pushing many of them into the mortality-churn compartment. In this scenario, managers of the digital transformation process have to react and develop new churn risk management systems that serve to keep potentially profitable customers in the engagement compartment through actions that can serve as vaccines against NWOM infection, and that can even generate PWOM for the company. And also develop cures for customers who have moved into the infected compartment, offering them cheaper alternatives or more in line with their digital competencies. And finally, for customers who are very unprofitable, exercise the abandonment option (Méndez-Suárez & Crespo-Tejero, 2021) and let them die, i.e. leave.

Another important managerial implication of this research is that digital transformation coupled with the pressure to make customers profitable show that the proportion of disengaged customers is 43.4% of the total; those high levels considered a service failure have become even more devastating to firms because disaffected customers can now damage firms to a much greater level (Donthu et al., 2021). Therefore, it becomes key for firms to better understand and manage the customer in service recovery trying to decrease the proportion of NWOM infected customers and measures should be implemented to anticipate the decline of a company's credibility (Mahrinasari, 2019) and use social media in organizational activities aimed at creating a positive image of an organization (Jędrzejczyk & Brzeziński, 2021), as well as develop CSR strategies that may serve to improve damaged reputations (Méndez-Suárez et al., 2022). Therefore, finding service failures and having the marketing levers to manage them as the knowledge of the SEIRM is essential.

### 5.2. Limitations and Future Lines of Research

There are some limitations that may become future avenues for research, such as replicating this analysis using the bank's current data once the digital transformation process is completed. Also, limitations related to the mathematical model that

does not use individual information on who will be infected by a NWOM or when a user will be infected. Another limitation in the same sense is the difficulty to contemporaneously adjust the NWOM comments of customers with their behavior with the bank regarding the level of engagement, the sentiments of their comments and ultimately their churn. In addition, we have assumed, following the approach used by the bank, that those customers who increased their annual GM were more engaged and more immune to NWOM, although we recognize that there are many other factors that can increase GM so we consider that these could be included in future research. Furthermore, we consider that the introduction of cause-effect relationships could include a greater level of detail to the results of the analysis and that this should be investigated in subsequent work. In addition, further research is needed to investigate whether digital transformation is having the same negative impact on customers today as it did in the initial periods of the process. And finally, the study focuses on the banking sector and could be extended to other contract customer sectors, as well as to other countries.

## 6. Conclusion

This article aimed to narrow the research gap regarding the consumers' negative reactions to digitally-intensive innovative financial services introduction in banks. The research applies an innovative epidemiological model to analyze the churn behavior of disengaged customers using data from a medium-sized Spanish commercial bank. The article provides new insights into the customer's journey through the different compartments, starting with NWOM exposure, contagion and recovery or eventual abandonment.

When dealing with digital transformation, better understanding of this customer infection process by NWOM warns banks marketing managers to the importance of additional monitoring efforts, especially on online media and customers relations. The study warns about the lack of digital transformation planning by banks and helps bank management understand the behavior of (possibly) infected disengaged customers that led them to abandonment, feeling that the company did not provide them with

another alternative due to the lack of reaction to viral marketing campaigns by angry customers. In this sense, the potential benefits of digital transformation can be offset by negative reactions from customers who do not understand that the changes are intended to improve the services provided to them.

After the data analysis and detailed discussion of the explored results, the present study found a positive answer to the research question whether compartmental models help to better understand the challenging behavior to digital transformation of disengaged customers when they perceive injustice in the customer relationship changes.

But the study also left unresolved questions opening new avenues of research: clearly, more work is needed to expand the scope of the innovative application of SEIRM models to solve marketing problems, in this line, it is necessary to replicate this research linking the WOM of customers in social networks with their behavior, to identify and classify them more accurately in one of the compartments explained in the model. In this vein, another line of research could also be able to explore the possible impact of reactive marketing and CSR strategies, i.e., vaccines, to help slow down the high levels of mortality, i.e., the loss of customers of companies undergoing digital transformation. In addition, the model's conceptual framework can be applied to other companies with contractual customers, but in sectors other than financial, to provide them with an analysis of their customers' behavior, which will serve to clarify the evolution of their portfolios. And finally, recognizing that the model analysis conducted in the research is short-term, it would be necessary to measure it by extending the analysis time beyond three years to have an unbiased measure of its influence in the future.

## Acknowledgment

Mariano Méndez-Suárez wants to acknowledge the funding of ESIC University under grant number ESIC 1-M-2017

## References

Akdim, K. (2021). The influence of eWOM. Analyzing its characteristics and consequences, and future research lines. *Spanish Journal of Marketing-ESIC*,

25(2), 239-259. <https://doi.org/10.1108/SJME-10-2020-0186>

Anand, A., Irshad, M. S., & Aggrawal, D. (2021). Understanding and predicting view counts of YouTube videos using epidemic modelling framework. In S. Patnaik, K. Tajeddini, & V. Jain (Eds.), *Computational management* (pp. 177-194). Springer International Publishing. [https://doi.org/10.1007/978-3-030-72929-5\\_8](https://doi.org/10.1007/978-3-030-72929-5_8)

Babutsidze, Z. (2018). The rise of electronic social networks and implications for advertisers. *Technological Forecasting and Social Change*, 137(January), 27-39. <https://doi.org/10.1016/j.techfore.2018.06.010>

Bampo, M., Ewing, M. T., Mather, D. R., Stewart, D., & Wallace, M. (2008). The effects of the social structure of digital networks on viral marketing performance. *Information Systems Research*, 19(3), 273-290. <https://doi.org/10.1287/isre.1070.0152>

Berman, S. J. (2012). Digital transformation: Opportunities to create new business models. *Strategy and Leadership*, 40(2), 16-24. <https://doi.org/10.1108/10878571211209314>

Bhattacharya, S., Gaurav, K., & Ghosh, S. (2019). Viral marketing on social networks: An epidemiological perspective. *Physica A: Statistical Mechanics and Its Applications*, 525, 478-490. <https://doi.org/10.1016/j.physa.2019.03.008>

Boogaard, B. K., Bock, B. B., Oosting, S. J., Wiskerke, J. S. C., & van der Zijpp, A. J. (2011). Social acceptance of dairy farming: The ambivalence between the two faces of modernity. *Journal of Agricultural and Environmental Ethics*, 24(3), 259-282. <https://doi.org/10.1007/s10806-010-9256-4>

Bowden, J. L. H., Gabbott, M., & Naumann, K. (2015). Service relationships and the customer disengagement – engagement conundrum. *Journal of Marketing Management*, 31(7-8), 774-806. <https://doi.org/10.1080/0267257X.2014.983143>

Canlas, K. (2019). Banks still using "pressure selling" tactics. Insurance Business. <https://www.insurancebusinessmag.com/nz/news/breaking-news/banks-still-using-pressure-selling-tactics-165725.aspx>

Carbó-Valverde, S., Cuadros-Solas, P. J., & Rodríguez-Fernández, F. (2020). The effect of banks' IT investments on the digitalization of their customers. *Global Policy*, 11(S1), 9-17. <https://doi.org/10.1111/1758-5899.12749>

Cooper, I., Mondal, A., & Antonopoulos, C. G. (2020). A SIR model assumption for the spread of COVID-19 in different communities. *Chaos, Solitons & Fractals*, 139(January), 110057. <https://doi.org/10.1016/j.chaos.2020.110057>

Costa-Climent, R., & Martínez-Climent, C. (2018). Sustainable profitability of ethical and conventional banking. *Contemporary Economics*, 12(4 Special Issue), 519-530. <https://doi.org/10.5709/ce.1897-9254.294>

Caporal, J. (2023). Study: Banking needs, digital banking trends, and consumer priorities. In *The Ascent*. <https://www.fool.com/the-ascent/research/>



- digital-banking-trends/
- Dalzotto, D., Basso, K., Costa, C., & Baseggio, H. W. (2016). The impact of affective and cognitive antecedents on negative word-of-mouth intentions. *International Review of Retail, Distribution and Consumer Research*, 26(4), 418–434. <https://doi.org/10.1080/09593969.2016.1157512>
- Donthu, N., Kumar, S., Pandey, N., Pandey, N., & Mishra, A. (2021). Mapping the electronic word-of-mouth (eWOM) research: A systematic review and bibliometric analysis. *Journal of Business Research*, 135(July), 758–773. <https://doi.org/10.1016/j.jbusres.2021.07.015>
- European Central Bank. (2022). *Official Interest Rates* [Data set]. [https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/key\\_ecb\\_interest\\_rates/html/index.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html)
- Ghosh, S., Gaurav, K., Bhattacharya, S., & Singh, Y. N. (2020). Ensuring the spread of referral marketing campaigns: a quantitative treatment. *Scientific Reports*, 10(1), 1–15. <https://doi.org/10.1038/s41598-020-67895-6>
- Goffman, W., & Newill, V. A. (1964). Generalization of epidemic theory. *Nature*, 204(4955), 225–228. <https://doi.org/10.1038/204225a0>
- Goldenberg, J., Libai, B., & Muller, E. (2001). Talk of the network: A complex systems look at the underlying process of word-of-mouth. *Marketing Letters*, 12(3), 211–223. <https://doi.org/10.1023/A:1011122126881>
- Grégoire, Y., Tripp, T. M., & Legoux, R. (2009). When customer love turns into lasting hate: The effects of relationship strength and time on customer revenge and avoidance. *Journal of Marketing*, 73(November), 18–32. <https://doi.org/10.1509/jmkg.73.6.18>
- Haenlein, M., & Kaplan, A. M. (2011). Evaluating the consequences of abandoning unprofitable customers: A comparison of direct and indirect abandonment strategies. *Zeitschrift Für Betriebswirtschaft*, 81(S2), 77–94. <https://doi.org/10.1007/s11573-010-0436-5>
- Haenlein, M., & Kaplan, A. M. (2012). The impact of unprofitable customer abandonment on current customers' exit, voice, and loyalty intentions: An empirical analysis. *Journal of Services Marketing*, 26(6), 458–470. <https://doi.org/10.1108/08876041211257936>
- Horváth, D., & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change*, 146(March), 119–132. <https://doi.org/10.1016/j.techfore.2019.05.021>
- Huefner, J. C. H., & Hunt, K. H. (2000). Consumer retaliation as a response to dissatisfaction. *Journal of Consumer Satisfaction, Dissatisfaction & Complaining Behavior*, 13, 61–82.
- Jabeen, F., Kaur, P., Talwar, S., Malodia, S., & Dhir, A. (2022). I love you, but you let me down! How hate and retaliation damage customer-brand relationship. *Technological Forecasting and Social Change*, 174(September 2021), 121183. <https://doi.org/10.1016/j.techfore.2021.121183>
- Jansen, N. (2019). The fiery, the lovely, and the hot – Analysis of online viral phenomena in social media. *Proceedings of the European Conference on Information Systems (ECIS)*, 0–16.
- Jędrzejczyk, W., & Brzeziński, S. (2021). The importance of social media in managing the image of the educational institutions. *Contemporary Economics*, 15(4), 457–466. <https://doi.org/10.5709/ce.1897-9254.460>
- Jiang, P., Yan, X., & Wang, L. (2017). A viral product diffusion model to forecast the market performance of products. *Discrete Dynamics in Nature and Society*, 2017. <https://doi.org/10.1155/2017/9121032>
- Kandhway, K., & Kuri, J. (2014). How to run a campaign: Optimal control of SIS and SIR information epidemics. *Applied Mathematics and Computation*, 231, 79–92. <https://doi.org/10.1016/j.amc.2013.12.164>
- Keeling, M. J., & Rohani, P. (2011). *Modeling infectious diseases in human and animals*. Princeton University Press.
- Kumar, N., & Mehrotra, R. (2022). A study of customer perception regarding issues and challenges in digital banking. *Journal of Positive School Psychology*, 6(5), 1874–1878.
- Lamrhari, S., Ghazi, H. El, Oubrich, M., & Faker, A. El. (2022). A social CRM analytic framework for improving customer retention, acquisition, and conversion. *Technological Forecasting and Social Change*, 174(October 2021), 121275. <https://doi.org/10.1016/j.techfore.2021.121275>
- Lee, M., & Cunningham, L. F. (2001). A cost/benefit approach to understanding service loyalty. *Journal of Services Marketing*, 15(2), 113–130. <https://doi.org/10.1108/08876040110387917>
- Lepthien, A., Papies, D., Clement, M., & Melnyk, V. (2017). The ugly side of customer management – Consumer reactions to firm-initiated contract terminations. *International Journal of Research in Marketing*, 34(4), 829–850. <https://doi.org/10.1016/j.ijresmar.2017.02.001>
- Li, P., Yang, X., Yang, L. X., Xiong, Q., Wu, Y., & Tang, Y. Y. (2018). The modeling and analysis of the word-of-mouth marketing. *Physica A: Statistical Mechanics and Its Applications*, 493, 1–16. <https://doi.org/10.1016/j.physa.2017.10.050>
- Liu, Y. (2006). Word of mouth for movies: Its dynamics and impact on box office revenue. *Journal of Marketing*, 70, 74–89. <https://doi.org/10.1016/j.dss.2016.11.002>
- Luo, X. (2009). Quantifying the long-term impact of negative word of mouth on cash flows and stock prices. *Marketing Science*, 28(1), 148–165. <https://doi.org/10.1287/mksc.1080.0389>
- Mahrinasari, M. S. (2019). Determinants of brand equity: Communication of corporate social responsibility (CSR) versus csr itself and company credibility. *Contemporary Economics*, 13(3), 317–334. <https://doi.org/10.5709/ce.1897-9254.316>

- Méndez-Suárez, M., & Crespo-Tejero, N. (2021). Why do banks retain unprofitable customers? A customer lifetime value real options approach. *Journal of Business Research*, 122, 621–626. <https://doi.org/10.1016/j.jbusres.2020.10.008>
- Méndez-Suárez, M., & Danvila del Valle, I. (2023). *Replication R code for SEIRM model in: "Negative word of mouth (NWOM) using compartmental epidemiological models in banking digital transformation"* (V1 ed.). Harvard Dataverse. <https://doi.org/10.7910/DVN/SCSNON>
- Méndez-Suárez, M., Monfort, A., & de Obesso, M. de las M. (2022). Real options appraisal for a reactive CSR strategy: The case of Facebook. *Economic Research-Ekonomska Istraživanja*, 1–16. <https://doi.org/10.1080/1331677X.2022.2135557>
- Montero Guerra, J. M., Danvila-del-Valle, I., & Méndez-Suárez, M. (2023). The impact of digital transformation on talent management. *Technological Forecasting and Social Change*, 188(October 2022). <https://doi.org/10.1016/j.techfore.2022.122291>
- Mora, E., Vila-Lopez, N., & Küster-Boluda, I. (2021). Segmenting the audience of a cause-related marketing viral campaign. *International Journal of Information Management*, 59(October 2019). <https://doi.org/10.1016/j.ijinfomgt.2020.102296>
- Nazifi, A., El-Manstrly, D., Tregear, A., & Auxtova, K. (2021). The impact of termination severity on customers' emotional, attitudinal and behavioral reactions. *Journal of Service Theory and Practice*, 31(1), 65–81. <https://doi.org/10.1108/JSTP-10-2019-0224>
- Nijssen, E. J., Schepers, J. J. L., & Belanche, D. (2016). Why did they do it? How customers' self-service technology introduction attributions affect the customer-provider relationship. *Journal of Service Management*, 27(3), 276–298. <https://doi.org/10.1108/JOSM-08-2015-0233>
- Pertusa-Ortega, E. M., Molina-Azorín, J. F., & Claver-Cortés, E. (2010). Competitive strategy, structure and firm performance: A comparison of the resource-based view and the contingency approach. *Management Decision*, 48(8), 1282–1303. <https://doi.org/10.1108/00251741011076799>
- Philp, M., & Ashworth, L. (2020). I should have known better!: When firm-caused failure leads to self-image concerns and reduces negative word-of-mouth. *Journal of Business Research*, 116(June 2019), 283–293. <https://doi.org/10.1016/j.jbusres.2020.05.018>
- Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, 92(11), 64–88. <https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition>
- Porter, M. E., & Heppelmann, J. E. (2015). How smart, connected products are transforming companies. *Harvard Business Review*, 114, 96–112. <https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies>
- Rampersad, G. (2020). Robot will take your job: Innovation for an era of artificial intelligence. *Journal of Business Research*, 116, 68–74. <https://doi.org/10.1016/j.jbusres.2020.05.019>
- Rimé, B. (2009). Emotion elicits the social sharing of emotion: Theory and empirical review. *Emotion Review*, 1(1), 60–85. <https://doi.org/10.1177/1754073908097189>
- Rodrigues, H. S. (2016). Application of SIR epidemiological model: new trends. *ArXiv Preprint ArXiv:1611.02565*. <https://doi.org/10.48550/arXiv.1611.02565>
- Sanders, E. (2000, July 21). System lets banks identify most profitable customers. *Los Angeles Times*. <https://www.latimes.com/archives/la-xpm-2000-jul-21-mn-56717-story.html>
- Schwab, K. (2017). *The Fourth Industrial Revolution*. Crown Publishing Group.
- Sharma, S. (2021). Modeling the role of information on the spread of online shopping. *Computational and Mathematical Methods*, 3(5), 1–13. <https://doi.org/10.1002/cmm4.1182>
- Smith, T. M., & Reece, J. S. (1999). The relationship of strategy, fit, productivity, and business performance in a services setting. *Journal of Operations Management*, 17(2), 145–161. [https://doi.org/10.1016/S0272-6963\(98\)00037-0](https://doi.org/10.1016/S0272-6963(98)00037-0)
- Soetaert, K., Petzoldt, T., & Setzer, R. W. (2010). Package deSolve: Solving initial value differential equations in R. *Journal of Statistical Software*, 33(9), 1–25. <https://doi.org/10.18637/jss.v033.i09>
- Wangenheim, F. V. (2005). Postswitching negative word of mouth. *Journal of Service Research*, 8(1), 67–78. <https://doi.org/10.1177/1094670505276684>
- Wilson, A. E., Giebelhausen, M. D., & Brady, M. K. (2017). Negative word of mouth can be a positive for consumers connected to the brand. *Journal of the Academy of Marketing Science*, 45(4), 534–547. <https://doi.org/10.1007/s11747-017-0515-z>
- Wiśniewski, R., Oleksiuk, I., & Iwanowska, B. (2021). Privacy of european citizens in the face of the development of new data-driven business models. *Contemporary Economics*, 15(4), 442–456. <https://doi.org/10.5709/ce.1897-9254.459>
- Woo, J., & Chen, H. (2016). Epidemic model for information diffusion in web forums: experiments in marketing exchange and political dialog. *Springer-Plus*, 5(1), 1–19. <https://doi.org/10.1186/s40064-016-1675-x>
- Woo, J., Lee, M. J., Ku, Y., & Chen, H. (2015). Modeling the dynamics of medical information through web forums in medical industry. *Technological Forecasting and Social Change*, 97, 77–90. <https://doi.org/10.1016/j.techfore.2013.12.006>
- Wood, J. A. (2021). Incorporating negative and positive word of mouth (WOM) in compartment-based epidemiology models in a not-for-profit marketing context. *Journal of Marketing Analytics*, 9(3), 199–209. <https://doi.org/10.1057/s41270-021-00112-z>