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Studying Kangen Technology Dissemination in Indian Subcontinent: A Mathematical Modeling Framework

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Abstract
Much research has been done on the character, types, and nature of adopters present in the market, wherein discussion has revolved around the adoption process in entirety, but less attention has been given to characterizing the types of these adopters in the market. By integrating principles from seminal models such as Rogers' Diffusion of Innovations and Bass Diffusion Model, the present work helps in identification of the adopters and predicting trends that delves into the diffusion dynamics of Kangen, a technology which is a notable innovation in the water purification and ionization industries and provides better hydration, helping with energy and focus. Critical insights into the Kangen technology dissemination process across India are offered by the results of applying the Innovation Diffusion Modeling Framework. The results highlight not only the rate and extent of adoption but also shed light on the profiles of different categories of imitators within the market.

Keywords- Bass model, External influencer, Kangen technology, Technology adoption, Word-of-Mouth influencer.

1. Introduction

In the contemporary landscape of technological advancement, sustainable consumer behavior (Trudel, 2019) and market dynamics are significantly shaped by the acceptance and spread of innovative items (Ratcliff & Doshi, 2016). Due to increased environmental concerns and awareness of the effects of daily decisions on the environment, adopting sustainable practices in consumer behavior has received attention recently. Water is a scarce resource that has attracted attention for its preservation and innovative sustainable technology. The scientific and technical community, followed by innovation, responds by creating standards to facilitate industry and economic activity (Agarwal et al., 2017) and lead to the adoption process by customers. Kangen Technology is a leading invention in the field of water purification and ionization systems (Cerbu, 2013). It has redefined water quality standards and is a subject of great interest for researchers studying technology adoption patterns.

Good health and well-being have become an intensified consciousness of every individual after the COVID-19 pandemic, and it has sparked an interest in multiple innovative technologies that can provide potential health benefits (Henry & Chambron, 2013). Among these various innovations and emerging trends, the health benefits of water ionization technology have enticed the attention among consumers for its adoption (Pandey & Aggrawal, 2025) and the high pH value and low surface tension of electrolyzed reduced water (ERW), the virus's envelope, made up of proteins and phospholipids, breaks down and exhibits inhibitory activity against the Severe Acute Respiratory Syndrome Coronavirus-2 (Okajima et al., 2021). As a potent antioxidant, hydrogen is thought to minimize oxidative stress, which may slow aging and boost energy

(Pisoschi et al., 2021). The creation of hydrogen-rich water is another important characteristic of water ionizers and as a potent antioxidant, hydrogen is thought to minimize oxidative stress, which may slow aging and boost energy (Pisoschi et al., 2021). Water ionizers are marketed to offer improved hydration, detoxification, and antioxidant properties, thus appealing to health-conscious consumers.

An exhaustive investigation into the diffusion dynamics of Kangen Technology (Cerbu, 2013), leveraging the robust framework of Innovation Adoption Modeling which has set up the need to quantify the adoption of Ionization technology. Understanding the adoption patterns and diffusion mechanisms of this transformative technology is crucial not only for elucidating its market penetration but also for unravelling the intricate web of factors shaping its acceptance and utilization across diverse user segments (Lotfi et al., 2014). Consumers consider a variety of criteria, including personal preference, experience, and word-of-mouth (Babbar et al., 2024), in addition to the mass media (Mahajan et al., 1990a). Such framework, rooted in the seminal works of Bass (1969) and Rogers (1962) in the diffusion of Innovations theory, offers a structured approach to understanding how new technologies permeate markets and social systems. The decision to focus on Kangen Technology provides an opportunity to explore the diffusion of environmentally significant innovation in a market that directly impacts public health and sustainability (Pandey & Aggrawal, 2024).

The diffusion of innovations within markets often follows identifiable patterns and stages, a phenomenon extensively studied and theorized by pioneers such as Everett Rogers (1962). By applying and adapting these theoretical frameworks to the unique context of Kangen Technology, this study seeks to unravel the nuanced pathways through which this innovation permeates various market segments and geographic regions in India.

This research aims to answer pivotal questions concerning the adoption dynamics of Kangen Technology wherein certain research gaps were identified, especially with respect to Indian Sub-continent, like,

- *What is the pace of acceptance of this new technology wherein water is created through an electrolysis process using a water ionizer?*
- *Acceptance of water ionizers, now a home appliance (that raises the pH of the drinking water) after the COVID-19 pandemic.*

This study aims to furnish actionable insights for informed marketing strategies, policy frameworks, and innovation within the water purification industry. The significance of this study contributes on technology adoption, empirical evidence and theoretical frameworks that could outline the understanding and management of innovative contributions in diverse Indian markets. Accessibility to clean and healthy water sources is global challenge and the implications of this research foster to public health, environmental sustainability, and societal well-being (Ronen & Kerret, 2020).

This paper aims to deliver an exhaustive and quantified analysis of the diffusion of Kangen Technology, enhancing the understanding of innovation adoption. The details of the article's structure are explained in the following section. The existing literature and background on diffusion theory, water ionizers, and their health benefits are presented in Section 2. Section 3 comprises a discussion of the bass model and its framework. Section 4 presents the implementation of sales data and the development of a model using bass diffusion theory. The discussion and interpretation are discussed in Section 5, followed by managerial implications in Section 6. Lastly, the conclusion, limitations, and Section 7 represent the future roadmaps.

2. Literature Review

The diffusion theory was first postulated by sociologist Gabriel Tarde in the late 19th century. Predictive models seek to develop explanations for how social strength impacts the diffusion and adoption process since diffusion is a social process, and many potential adopters' acceptance was encouraged by their peers' social strength (Aggrawal et al., 2021). It can include the adoption of new goods, technology, and lifestyles, as well as the development of new epidemics, such as the still-active COVID-19 pandemic. To enhance and direct innovation management, prominent aggregate models like innovation characteristics (Rogers, 1995) and the Bass model (Bass, 1969), as well as seminal individual-level models like the technology acceptance model (Venkatesh & Davis, 2000) and the theory of planned behavior (Ajzen, 1991) are still widely used. Understanding consumer behaviour in sales, which is often influenced by spatiotemporal uncertainties that vary across different regions over time, Bayesian Deep Learning modelling as a probability distribution captures the dynamic and complex nature of consumer behaviour (Li et al., 2024).

Product adoption, particularly with disruptive technologies, has a significant impact on the financial foundation of entrepreneurial enterprises that frequently develop them (Kirchhoff et al., 2013). Many times, the adoption of the products in the market is explained as the behaviour of sigmoidal dynamics (Lotfi et al., 2014). Rogers (1995) claims that when businesses that have embraced an innovation encounter business that have not, their clearly superior performance will persuade non-adopters to do the same, leading to the fast growth stage of an S-shaped diffusion curve. Another popular innovation diffusion model is the marketing time cumulative adopters. The model assumes that innovation adopters comprise two groups. One group is influenced only by mass-media communication (external influence), and the other group is only influenced by word-of-mouth communication (internal influence). Bass termed the first group '*Innovators*' and the second group '*Imitators*' (Bass, 1969). This explains the product life cycle in the longer run, which is demonstrated in **Figure 1**. On the adoption curve, innovators, early adopters, early majority, late majority, and laggards are in the sequential processes (Rogers, 1962). Existing research has already explained adoption behaviour; however, the market dynamics are being changed based on the social and economic behaviour of the consumer. Nowadays, technology frequently causes disruptions. Thus, it is critical for products to be sustainable so that they may last a long time for customers and provide the benefits initially. Peer evaluation is a crucial component of many platforms that help people make decisions in their day-to-day activities. The concept of the presented work has been originated from the theory of adoption and spread put forth by Anand et al. (2016), Bass (1969, 2004), Kumar et al. (2023), Mahajan et al. (1990a, 1990b), Rogers (1962), and Singhal et al. (2019).

Innovation diffusion models are frequently used in marketing and business to forecast the adoption of new products or services. Many of the researchers have employed these models for descriptive conclusions in addition to forecasting. For instance, the Bass model was used to explain why consumer durable goods product life cycles (PLCs) are shortening due to rapid technological development (Olshavsky, 1980), and this is also demonstrated that the nationalization of oil production is a pattern of social interaction phenomena (Kobrin, 1985).

Various factors and drivers, such as personal, societal, situational, and demographic aspects, impact behavior that is environmentally sustainable (Nguyen & Johnson, 2020). Water ionizers are one of the right choices for healthy water consumption for human life, and this study shows the indicators responsible for igniting consumer perceptions of adopting water ionizers. Human health and well-being frequently align with sustainable practices (Ronen & Kerret, 2020). Given its alkaline composition and health benefits, consumers might view ionized water from water ionizers as a healthier choice. To analyze the adoption of water ionizers, it is necessary to comprehend the relationship between health beliefs and sustainable consumption patterns (Tanner & Kast, 2003). Convenience and pragmatism in daily living must be

integrated into sustainable activities. To assess whether water ionizers are sustainable, consumers consider aspects like maintenance needs, usability, and how easily they can be incorporated into regular routines. Also, a vital component of sustainable consumer behavior (Trudel, 2019) is belief in the efficiency and dependability of technology. Customers' confidence in the safety, reliability, and moral ramifications of ionization technology and its use and manufacture provides longevity in business and a healthy lifespan in society. Most water ionizers from good brands are ISO 14001 certified (ISO 14001:2015, 2015), which authorizes the product for best practices and environmental management strategies (EMS) and leads toward environmental sustainability. EMS strives to innovate best practices for environmentally sustainable products like water ionizers. The sustainability of water ionizers can be evaluated from various angles, including their environmental impact, energy efficiency, and long-term economic viability. With the demand for sustainable products by customers and regulatory obligations on organizations, sustainability is an extreme goal to consider in terms of raw material, innovation, product, and process design. Product awareness among consumers and sustainability labeling impact consumers' perceptions of products, their desire to behave, and their actual purchasing behaviors (Majer et al., 2022).

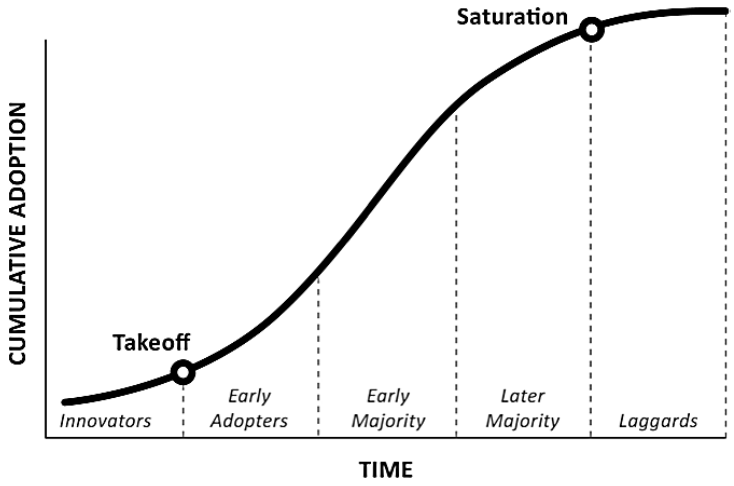

Figure 1. S - Curve model of diffusion process (Source: Author creation).

The comprehensive understanding of water, which is one of the essential liquids in the human body (Lu et al., 2023), and its use inside the human body directs the perusal to consumers for analyzing the factors for the adoption of such a technological product in daily life. Human body parts are mostly made up of water. For example, the brain consists of 80-85% water, the heart 70-80%, etc. Keeping all body parts hydrated helps maintain body parts' health and reduces the rate of aging. With aging, the percentage of water in the human body decreases (Pocock et al., 1981). Water ionizers are products that alter normal water into electrolyzed reduced water (ERW) or alkaline ionized water (AIW). EDW depicts critical properties such as alkalinity, negative oxidation-reduction potential (ORP), micro-clustering, and a high content of dissolved hydrogen, which distinguish it from regular tap or reverse osmosis (RO) water (Ignacio et al., 2012). Alkaline ionized water (AIW) produced from water ionizers offers several potential health benefits (Henry & Chambron, 2013), like hydration, antioxidant properties, alkalinity, detoxification, and improved digestion. It is shown that reduced water suppresses oxidative stress-related diseases such as diabetes, arteriosclerosis, cancer, neurodegenerative diseases, and the side effects of hemodialysis (Shirahata et al., 1997). Studies have demonstrated that alkaline ionized water protects against the body's accumulation of

lipids and cholesterol (Jin et al., 2006). It is evident that electrolyzed reduced water (ERW) causes telomere shortening in cancer cells (Shirahata et al., 2012). It suppresses tumor angiogenesis by scavenging intracellular reactive oxygen species (ROS), secretion of vascular endothelial growth factor, and suppressing gene expression (Ye et al., 2008). ERW suppresses microorganisms and the growth of cancer cells (Hamasaki et al., 2005), and it induces apoptosis in human leukemia HL60 cells when combined with glutathione (Tsai et al., 2009).

Further studies on ionized water revealed that the bandwidth of ERW is less than tap water (LeBaron et al., 2022) and subjected to approx.170 nuclear magnetic resonance (NMR). This depicts a type of rearrangement of the ionized water, specifically the presence of a smaller micro-cluster (Hayashi, 1995). It is often claimed that ionized water carries less micro-cluster than regular tap water, improving its ability to penetrate water molecules inside human organs (Mohr, 2016). The higher pH ionizes water molecules, increasing their solubility and subsequent extraction (Kun-Kul, 2005), which contributes to the removal of oil-based pesticides from foods and claims that micro-clustering is responsible for the ability of this high-pH water to emulsify the oil. The result of ORP with a negative charge relates to a charge with a negative value of permanent antioxidant activity. ORP measures the antioxidants in water by checking its electrical conductivity for unsafe radicals due to the valuable antioxidants. Antioxidants resist diseases like cancer, cardiovascular disease, and immune disorders (Ignatov, 2017).

A study of the literature on modeling frameworks for innovation diffusion and adoption offers insights into the methods, applications, and theoretical foundations of diverse approaches to comprehending the diffusion and acceptance of innovations within populations. The sales of water ionizers in Indian society prevail in the interest of an individual's health. People are buying water ionizers because they think the health advantages of ionized water hold the key to an eternally healthy life. Over the years, the adoption of water ionizers followed by RO, or packaged drinking water, has been one of the most popular topics in the sustainability of a healthy life. Target audience, sales cycle, and customer relationship play vital roles in modeling sales for B2C (Business-to-Consumer) versus B2B (Business-to-Business). B2C models focus on individual consumers, while B2B models target businesses and organizations. However, the Sales cycle is longer in B2B than in B2C. In India, the direct selling industry is evolving and focusing on a hybrid approach where the end customer is considered a new business entity.

Drawing on rising sales numbers across different regions, the framework by Bass has been chosen to research sales data to investigate the implications of the increasing adoption of water ionizers in Indian society, keeping in mind the foundational elements for the work given in this paper. This study attempts to close this gap in the literature by reporting sales data from seven years in the Indian region and navigates through the complexities of the diffusion process, aiming to identify and quantify the various adopters into those of innovators and imitators.

3. Insights from Bass Model and its Framework

The Bass model, first presented by Bass (1969), is one widespread and accepted mathematical model for analyzing the dissemination of innovations through a population by predicting the total number of adopters at any given time. The cognition of model offering details of new ideas, goods, or technology is embraced over time and can be partitioned into two categories of potential adopters:

- *External influencer*: The term describes motivations or elements that come from sources outside of a person, group, or system and influence choices, actions, or results. Individuals, groups, or entire societies may be impacted by these effects, which can originate from a variety of sources, including social, cultural, economic, environmental, or technical variables.

- *Word-of-Mouth influencer*: The term describes the persuasive power that verbal dialogues of personal suggestions, perspectives, or points to have over other people's decision-making processes. It is a way for people to communicate with friends, family, coworkers, and acquaintances about their experiences, preferences, or endorsements of goods, services, or ideas.

3.1 Hypothesis Building

Using the Bass Model to examine water ionizers' Kangen technology sales, several theories can be developed to investigate the variables affecting the acceptance and dissemination of this water filtration technology. Based on the role of innovator, imitator, and market penetration, the following theories are possible to draw using the bass model:

***H*11:** *Word-of-mouth inspiration is influential in the states of India.*

***H*12:** *External influence is influential in the regions under consideration.*

To get hold of these assertions, as stated earlier, we will now make use of the modeling framework by Bass, and in order to do that, let us check the various requisites.

3.2 Notations

The following notations have been used in this work are as follows:

$N(t)$: Expected number of adopters by time t with $N(0) = 0$.

$F(t)$: Probability distribution function for the Adoption Process.

m: Total market size.

b: Adoption rate.

p: Co-efficient of innovation.

q: Co-efficient of imitation.

3.3 Re-examining Bass Model

Bass Model assumes that buyers can be classified into two broad categories based on their buying patterns. He called the initial buyers Innovators since they are purchasing the technology based on external influence, and he called the other set imitators those who are buying under someone else's influence. Since the inception of this model in the marketing domain, it has been widely utilized by the management discipline. The mathematical structure of this model is straightforward to understand and can be understood from the Equation (1) given below.

$$\frac{d}{dt}N(t) = p\big(m - N(t)\big) + q\frac{N(t)}{m}\big(m - N(t)\big) \quad (1)$$

The mean value function obtained under the initial condition $N(0) = 0$ is

$$N(t) = m\left(\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}\right)e^{-(p+q)t}}\right) \quad (2)$$

It is noted that Equation (1) can also be expressed as

$$f(t) = \frac{dF(t)}{dt} = [p + qF(t)][1 - F(t)] \quad (3)$$

Therefore, Equation (2) can be written as $N(t) = m \cdot F(t)$.

where, $F(t)$ is the cumulative fraction of adopters by time t.

Integration of Equation (3) yields the S-shaped cumulative adoption distribution, $F(t)$ captured by the Bass Model. Further, the differentiation of $F(t)$ gives the non-cumulative adopter's distribution representing the specified adoption process; $f(t) = \frac{dF(t)}{dt}$and can also be understood as the fraction of adopters at time *t*. As bifurcated by Bass and then quantified by Mahajan et al. (1990b), these distributions are given by

$$F(t) = \left(\frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}\right)e^{-(p+q)t}} \right) \quad (4)$$

and,

$$f(t) = \frac{p(p+q)^2 e^{-(p+q)^t}}{\left(p+qe^{-(p+q)t}\right)^2} \quad (5)$$

Figure 1 depicts the non-cumulative buyer's distribution $f(t)$, underlying the Bass Model (Mahajan et al., 1990a), So, its peak, $f(T^*)$ or $F(T^*)$, at time, T^*can be derived and occurs when

$$T^* = -\frac{1}{(p+q)} ln\left(\frac{p}{q}\right) \quad (6)$$

$$F(T^*) = \frac{1}{2} - \frac{p}{2q} \quad (7)$$

$$f(T^*) = \frac{1}{4q}(p+q)^2 \quad (8)$$

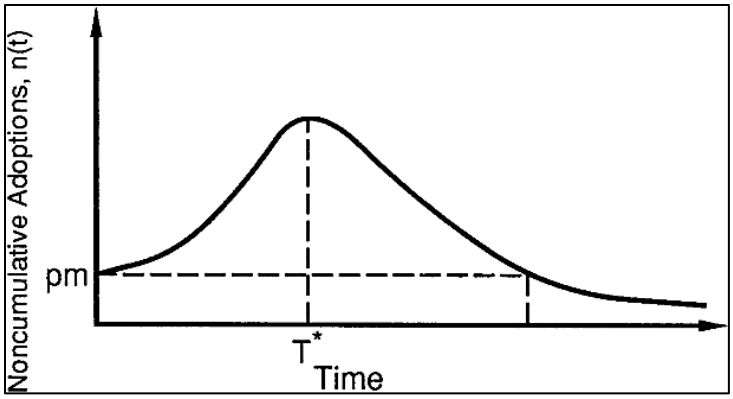

Figure 2. The adopter distribution (Source: Authors creation).

Given Equations (3) through Equation (6), we can figure out certain distinguishing features of the Bass model (Aggrawal et al., 2021; Mahajan et al., 1990b). First, note from Equation (5) that $f(t=0) = f(t=2T*) = p$. It is shown in **Figure 2** that the non-cumulative adopter distribution is symmetric with respect to time around the peak time $T*$ up to $2T*$. According to the Bass model, $p[1-F(t)]$ in Equation (3) represents the adoption happening via the innovation process and are thus termed '*innovators*. On the other hand, the term $qF(t)[1-F(t)]$ in Equation (3) represents adoption happening because of imitation. These buyers are hence termed as '*imitators*' (refer to **Figure 3** to understand the difference). The aforesaid modelling analogy can also be seen in other diversified research areas like those of software reliability which is present in the works of (Kapur et al., 2011; Yamada, 2014).

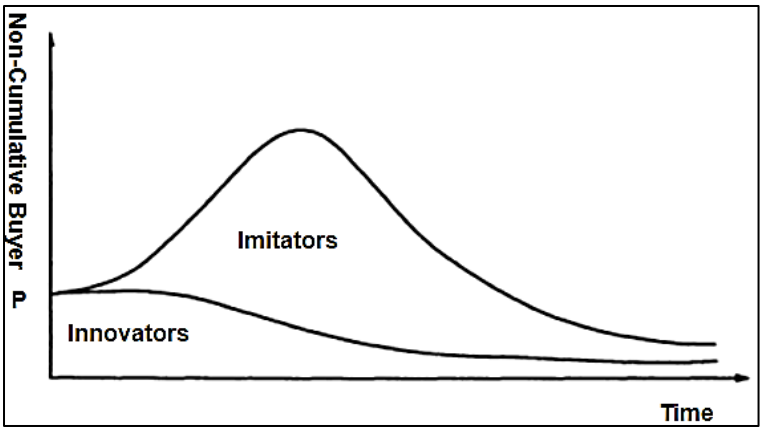

Figure 3. Buyers as per their purchase behavior (Source: Authors creation).

As a manager, especially with respect to a new technological product, one needs to find who is purchasing in which manner so that the various marketing strategies can then be strategized. For that, one should have the probable count of the number of buyers in each category. For this, using the conceptualization given by Mahajan et al. (1990b), we have quantified the number of buyers for the technological product in consideration. Since the product is a newer entry in the Indian Market, it would be great to have the exact scenario of the number of External Influencers and Word-of-Mouth influencers in the various regions of India.

For this, as taken earlier, $F(t)$ is a cumulative fraction of adopters by time t. Since, according to the Bass Model, there are two categories of buyers, $F(t)$ can be assumed to be comprised of two components $F_1(t)$: corresponding to innovators and $F_2(t)$corresponding to imitators wherein, the total fraction of innovators $F_1(t)$ between any two time periods, say t_0 and t_F $(t_F > t_0)$ is given by

$$F_1(t) = p\int_{t_0}^{t_F}[1 - F(t)]dt \tag{9}$$

Because $F(t)$ it is given by Equation (4). Hence, $F_1(t)$ it can be interpreted as:

$$F_1(t) = p\int_{t_0}^{t_F}\left[1 - \frac{1-e^{-(p+q)t}}{1+\left(\frac{q}{p}\right)e^{-(p+q)t}}\right]dt$$

$$= p\int_{t_0}^{t_F}\left[\frac{p+qe^{-(p+q)t}-p\left(1-e^{-(p+q)t}\right)}{p+qe^{-(p+q)t}}\right]dt$$

$$= p\int_{t_0}^{t_F}\left[\frac{(p+q)e^{-(p+q)t}}{p+qe^{-(p+q)t}}\right]dt$$

Put $Z = e^{-(p+q)t}$ or $dZ = -(p+q)e^{-(p+q)t}\,dt$. Therefore,

$$F_1(t) = -p\int_{z_0}^{z_f}\frac{dZ}{p+qZ}$$

$$= \frac{-p}{q}ln[(p+qZ)]_{z_0}^{z_f}$$

$$= \frac{p}{q}ln\left[\frac{p+qe^{-(p+q)t_0}}{p+qe^{-(p+q)t_f}}\right]$$

Substitution of $t_0 = 0$, $t_f = t$ in the above equation, yields

$$F_1(t) = \frac{p}{q} ln \left[\frac{1+\frac{q}{p}}{1+\frac{q}{p}e^{-(p+q)t}} \right] \quad (10)$$

Having the result for Innovators, the proportion of imitators can be calculated as follows:

$$F_2(t) = 1 - F_1(t)$$

$$\Rightarrow F_2(t) = \left[1 - \frac{p}{q} ln \left[\frac{1+\frac{q}{p}}{1+\frac{q}{p}e^{-(p+q)t}} \right] \right] \quad (11)$$

Also, adapting the Bass Diffusion Model to account for real-world complexities such as product obsolescence and market saturation involves extending the basic model to incorporate additional factors and dynamics:

$$f(t) = \frac{dF(t)}{dt} = ([p + qF(t)][1 - F(t)]) - \delta F(t) \quad (12)$$

where, δ is the decay rate representing product obsolescence.

and, market saturation can be addressed by adjusting the market potential parameter *m* over time. As the market approaches saturation, the effective market potential decreases, which can be modelled by making *m* a function of time.

$$f(t) = \frac{dF(t)}{dt} = ([p + qF(t)][1 - F(t)]) * (1 - F(t)/m(t))) \quad (13)$$

$m(t)$ is the time-varying market potential, which decreases as the market saturates.

4. Data Set and Model Validation

To understand the quantification of the model discussed above, it has been validated on the sales data collected for the water ionization technique Kangen Technologies by Enagic. The data comprises several states of the Indian Sub-continent, and secondary sales data from 2016 to 2022 has been arranged from the Enagic's sales team. The sales data is analyzed across Indian regions like East, West, North, and South to predict potential sales. Sales data from the East Region is considered Data Set I, followed by the West Region, which is considered Data Set II; the North Region is considered Data Set III; the South Region is considered Data Set IV and represented as DS-I, DS-II, DS-III and DS-IV respectively. The analysis has run on R-Studio using R code.

After estimation, the parameters of the model and values have been listed in **Table 1**. Based on the obtained model parameters, the performance measures are derived for Model Fit and hypothesis testing, as presented in **Table 2**. A Closure value of R^2 confirms that our quantified model fits the data reasonably well. Furthermore, **Table 3** contains the actual and predicted values along with the number of adopters (innovators and imitators) for the various states of India.

Table 1. Model parameters output.

Parameters	Data sets			
	DS-I	DS-II	DS-III	DS-IV
m	10043.94	101240.8	45029.06	71197.98
p	0.003710241	0.002981221	0.00487265	0.004226346
q	0.1897697	0.2191046	0.135289	0.127112

Source: Authors.

Table 2. Model fit and hypothesis testing.

Model fit	Data sets			
	DS-I	DS-II	DS-III	DS-IV
F value	39.13	94.01	61.28	148.9
R^2	0.7579	0.8826	0.8306	0.9226
AIC	340.11	516.65	456.79	385.68
Hypothesis testing parameters				
p- Value	0.000014	0.000000007	0.000006	0.00000001
t – Test	5.354	8.546	5.692	8.337

Source: Authors.

Table 3. Dataset wise actual and predicted values.

Time	DS-I				DS-II			
	Actual	Predicted	Innovators	Imitators	Actual	Predicted	Innovators	Imitators
2016 Q1	12	40.947	37.1918	3.75526	130	336.837058	301.337119	35.4999391
2016 Q2	33	90.189	74.2168	15.972	302	754.304531	601.554006	152.750525
2016 Q3	56	149.29	111.041	38.2533	457	1270.76243	900.383771	370.378657
2016 Q4	77	220.08	147.625	72.4561	601	1908.24669	1197.49943	710.747264
2017 Q1	112	304.63	183.922	120.708	914	2692.93553	1492.50223	1200.43331
2017 Q2	164	405.29	219.876	185.418	1328	3655.52436	1784.90872	1870.61564
2017 Q3	219	524.68	255.422	269.262	1726	4831.40597	2074.13697	2757.26901
2017 Q4	278	665.65	290.487	375.161	2147	6260.50871	2359.49264	3901.01607
2018 Q1	367	831.19	324.983	506.211	2807	7986.59759	2640.1564	5346.44119
2018 Q2	524	1024.4	358.815	665.579	3735	10055.8034	2915.17444	7140.62897
2018 Q3	679	1248.2	391.875	856.349	4810	12514.1329	3183.45484	9330.67807
2018 Q4	834	1505.4	424.043	1081.31	5776	15403.7618	3443.77316	11959.9887
2019 Q1	992	1797.9	455.191	1342.67	7283	18758.0598	3694.79096	15063.2688
2019 Q2	1174	2127	485.187	1641.79	9598	22595.5734	3935.09082	18660.4826
2019 Q3	1517	2492.7	513.894	1978.81	12439	26913.5996	4163.23015	22750.3694
2019 Q4	1770	2893.5	541.178	2352.34	14721	31682.4409	4377.81342	27304.6275
2020 Q1	2033	3326.2	566.914	2759.3	18246	36841.7903	4577.57874	32264.2115
2020 Q2	2415	3785.8	590.993	3194.76	23208	42300.7139	4761.4902	37539.2237
2020 Q3	2993	4265.4	613.328	3652.1	28850	47942.2089	4928.82358	43013.3853
2020 Q4	3449	4757.1	633.858	4123.28	32893	53632.2926	5079.23151	48553.0611
2021 Q1	3714	5252	652.554	4599.4	36196	59232.3244	5212.77632	54019.5481
2021 Q2	4074	5740.7	669.424	5071.27	41526	64612.2503	5329.92402	59282.3263
2021 Q3	4739	6214.6	684.505	5530.11	47893	69662.1583	5431.50082	64230.6575
2021 Q4	5197	6666	697.867	5968.17	53142	74300.0816	5518.6203	68781.4613
2022 Q1	5464	7088.8	709.606	6379.17	56724	78475.1275	5592.59427	72882.5332
2022 Q2	5845	7478.4	719.837	6758.55	62556	82166.2397	5654.84105	76511.3987
2022 Q3	6574	7832.2	728.688	7103.54	68995	85377.7795	5706.80244	79670.9771
2022 Q4	7036	8149.3	736.294	7413.02	74224	88133.4344	5749.87685	82383.5576
Time	**DS-III**				**DS-IV**			
	Actual	**Predicted**	**Innovators**	**Imitators**	**Actual**	**Predicted**	**Innovators**	**Imitators**
2016 Q1	49	234.31	218.852	15.4537	223	320.116108	300.244625	19.8714834
2016 Q2	102	500.87	436.486	64.3814	512	681.666615	599.0504	82.6162146
2016 Q3	206	803.64	652.734	150.904	842	1089.4866	896.232139	193.254464
2016 Q4	318	1146.9	867.41	279.499	1162	1548.82661	1191.58334	357.243266
2017 Q1	517	1535.3	1080.31	454.99	1713	2065.34556	1484.87445	580.471111
2017 Q2	734	1973.7	1291.19	682.511	2431	2645.08882	1775.85115	869.23767
2017 Q3	1168	2467.3	1499.8	967.456	3139	3294.44727	2064.23286	1230.21441
2017 Q4	1652	3021.3	1705.87	1315.4	3991	4020.09289	2349.71134	1670.38155
2018 Q1	2150	3641	1909.08	1731.97	4535	4828.88632	2631.94972	2196.9366
2018 Q2	2573	4331.8	2109.09	2222.74	5231	5727.75169	2910.58195	2817.16974
2018 Q3	3398	5098.6	2305.56	2793.02	6037	6723.51479	3185.21287	3538.30192
2018 Q4	4266	5945.7	2498.1	3447.6	6859	7822.70176	3455.41902	4367.28274

Table 3 continued…

2019 Q1	4928	6876.9	2686.3	4190.57	7759	9031.29743	3720.75041	5310.54703
2019 Q2	5575	7894.7	2869.76	5024.97	8945	10354.4654	3980.73338	6373.73199
2019 Q3	6772	9000.6	3048.04	5952.51	10117	11796.2354	4234.87474	7561.36066
2019 Q4	7994	10194	3220.73	6973.26	11534	13359.1692	4482.66725	8876.50192
2020 Q1	8921	11473	3387.38	8085.39	13026	15044.0193	4723.59654	10320.4228
2020 Q2	9950	12833	3547.61	9284.92	15069	16849.4035	4957.14947	11892.254
2020 Q3	11464	14267	3701.03	10565.6	16938	18771.5182	5182.82375	13588.6944
2020 Q4	12911	15766	3847.29	11918.9	19195	20803.9219	5400.1387	15403.7832
2021 Q1	13866	17320	3986.11	13334	20775	22937.4155	5608.64666	17328.7688
2021 Q2	14902	18915	4117.26	14798.2	22939	25160.0464	5807.94469	19352.1017
2021 Q3	16751	20538	4240.56	16297.1	24911	27457.2551	5997.68596	21459.5692
2021 Q4	18679	22171	4355.91	17815.4	27323	29812.172	6177.59017	23634.5818
2022 Q1	19783	23800	4463.32	19337	29135	32206.0596	6347.45248	25858.6071
2022 Q2	20963	25409	4562.83	20846.2	31615	34618.8792	6507.15017	28111.7291
2022 Q3	22935	26982	4654.58	22327.8	33898	37029.9486	6656.64682	30373.3018
2022 Q4	24820	28507	4738.78	23767.9	36608	39418.6453	6795.99357	32622.6517

Source: Authors.

Trends of Actual and predicted sales in all four regions are represented in the graph below. **Figures 4**, **5**, **6**, and **7** show the predictive cumulative sales in all four regions in the Indian continent. The higher values of *F*- value mentioned in **Table 2** are significant and follow the Bass adoption curve in all the regions. The *F*-value (148.9) and R^2 (0.9226) in the South region are the highest, and the cumulative graph of the South region is the best-fit model for innovation and adoption of the product.

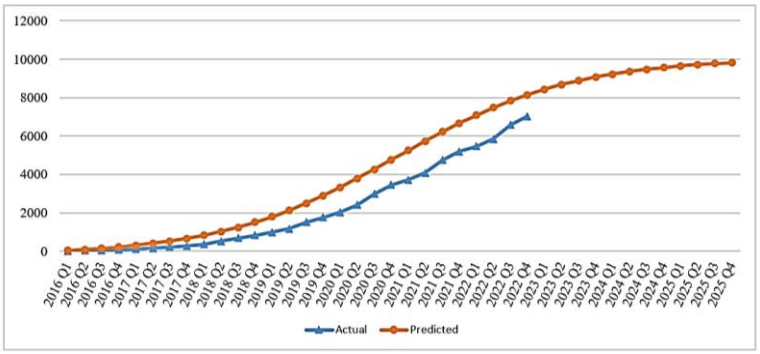

Figure 4. Cumulative sales of east region (DS-I) (Source: Authors).

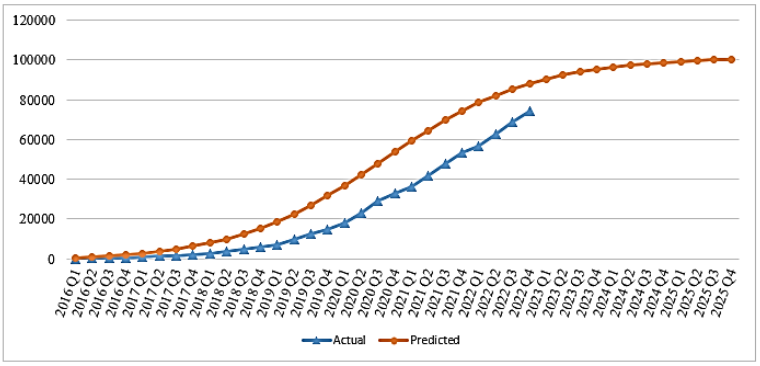

Figure 5. Cumulative sales of west region (DS-II) (Source: Authors).

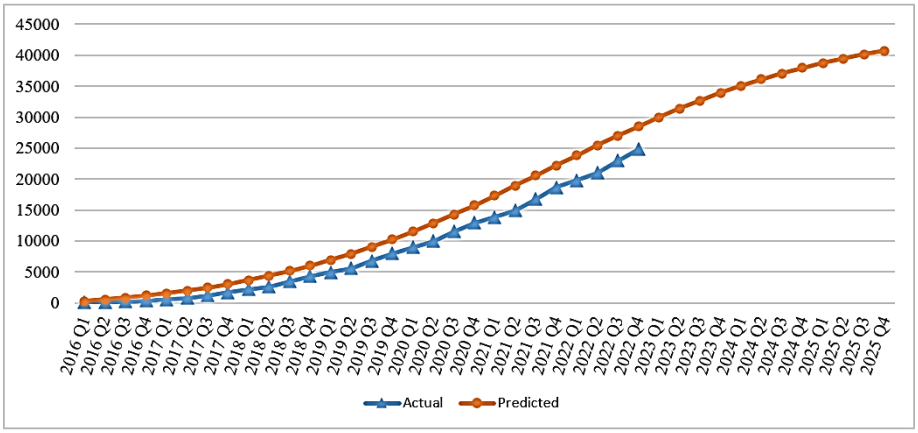

Figure 6. Cumulative sales of north region (DS-III) (Source: Authors).

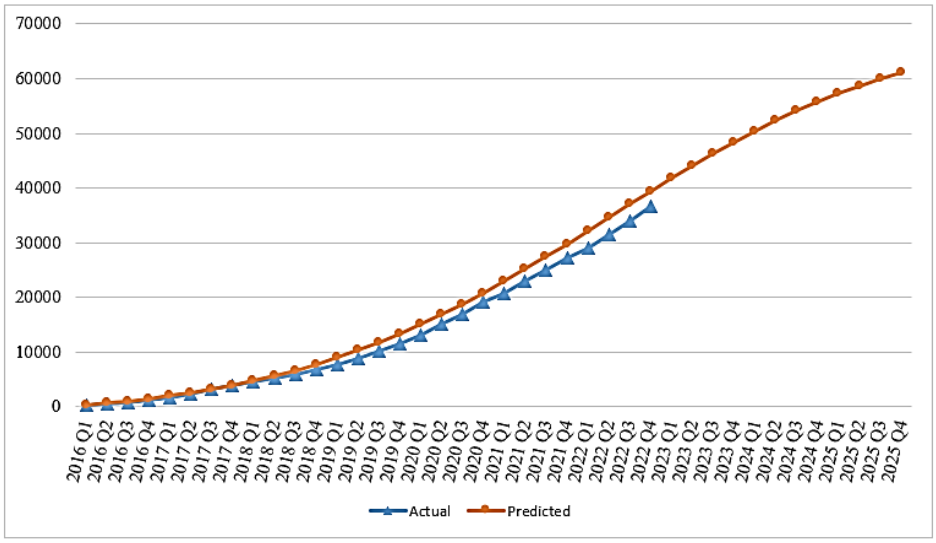

Figure 7. Cumulative sales of south region (DS-IV) (Source: Authors).

The cumulative Kangen's sales data across the regions East, West, North, and South, shows a steady and consistent growth indicating a high potential of adoption rate over the study period. This trend suggests a strong and growing market for Kangen technology in these regions. The above sales graphs depict the adoption dynamics implying the roles of innovators and imitators in the diffusion process. The observed trends provide insights into the market penetration and growth potential of Kangen technology in different regions in future.

5. Discussion & Interpretation

In the Bass model, it is assumed that the potential market consists of three types of consumers. Two of these represent different classes of innovators, i.e., those consumers who are the first to adopt the product. There are also consumers who are imitators of the innovators, and finally, the potential market also consists of a group of potential consumers who will not adopt the product no matter how long they are exposed to it. The

model determines the total number of adopters in the market, which is the sum of the innovators and the imitators, by assuming that the customer accepts and adopts the product according to a saturation distribution.

The basic assumption of the Bass model is that customers adopt a product by considering the successive adopters as well as their innovative effect and the imitation effect. The process of purchase by the imitative effect slows down as time passes, while purchases by the innovative effect increase over time, and the process of purchase slows down little by little. Market potential determines the success or failure of the product company directly, and market potential appears by the innovation saturation effect, which is the number of adoptions due to the development of products, and by imitation saturation effect, which is the number of adoptions due to the expansion of customers.

As can be seen from the **Table 2**, the following observations can be made:

- The word-of-mouth effect in the West region is more prevalent than in any other region. The value of the coefficient of imitation (q) in the western region is higher than in any other region, as shown in **Table 1**. As per hypothesis $H11$, the word-of-mouth influence is not just influential but also more prominent in the western region concerning other regions of the country.
- Other physical interpretation that can be drawn from the tabular values is that in the West region, word-of-mouth plays an influential role on consumer perception and conduct in comparison to the consumers' other regions. Realizing the impact of word-of-mouth in the West emphasizes the pertinence of customer tactics, knowledge of product characteristics and health benefits, and strategic marketing activities catered to local consumer preferences and behavior patterns.

Furthermore, the following observations can be made about the second hypothesis:

- From **Table 1**, the coefficient of innovation (p) in the North and South regions are equivalent and more than that of the South Region, and the coefficient of imitation (q) is less in comparison to the West region. The water ionizers are technologically enhanced instruments that use the electrolysis method to process alkaline and acidic waters as an output. The result shows that product adoption in all regions has good potential to increase sales in the market. Also, based on the Akaike's Information Criterion (AIC) values calculated for the sales data from the East, West, North, and South regions, the East region has the lowest AIC value (340.11), indicating that the Bass Model fits the sales data for this region the best which signify the model captures the dynamics of innovation and imitation in the East region more accurately than in the other regions. Advertisements and other promotional campaigns do play a significant role in the North and South regions. Consumers are adopting products based on product features and their benefits due to external influences.
- In comparison to other regions, external forces are highly signific in the North and South in comparison to word-of-mouth impact. This could mean that in these areas, customer behavior and product acceptance are extremely influenced by individuals' own judgment of adoption based on the pivotal product traits and their potential benefits. Marketing tactics in the North and South can benefit from an understanding of the role that outside influences play in spreading word-of-mouth.

Yet, as per another observation, External factors in the East region play a less significant role in influencing consumer behavior than other regions and the values of p and q for eastern region lies in between the values of other three regions and have learning parameters more than those of north and south region but lesser than western region. This could indicate that other factors such as product quality, price, or personal preferences have a stronger impact on purchasing decisions in the eastern region. Businesses that can effectively navigate regional differences and manage consumer's specific requirement in the East region are nicely placed to succeed in the competitive marketplace. Considering the value of innovation and

imitator from **Table 3,** 2017 Q3, 2017 Q2, 2018 Q2, and 2018 Q3 for DS-I, DS-II, DS-III, and DS-IV, respectively, are the breakeven points once word of mouth is more influential than the external effect. Since 2016, sales in all regions have grown, potentially defining the pace of acceptance of new technology.

It can also be observed that the value of imitators has significantly risen across all the regions of India, which depicts the acceptance of water ionizers as an essential source of drinking water post-COVID-19 pandemic for the year 2020. In the east, west, and south, the sales of water ionizers in 2020 are nearly twice as high as those in 2019, while in the north, the sales are nearly one and half times than those from the previous year. Even before the pandemic, consumers became more conscious of the health advantages of drinking ionized alkaline water and this increased awareness facilitated a consistent rise in sales. The growing market was driven by consumers' increasing awareness of the possible health benefits linked to alkaline water generated by ionizers. Even though the COVID-19 pandemic initially caused disruptions to consumer buying patterns and sales channels, the emphasis on health and wellness has ultimately led to a sustained or even increased demand for water ionizers during the pandemic. The market for water ionizers increased because of individual's awareness of wellness and health products. Consumers sought products offering potential health benefits such as antioxidants and improved hydration properties.

6. Managerial Implication

The postulation of Bass model for analysis of the adoption of Kangen's technology will provide holistic insight to marketers and end consumers. Applying an Innovation Diffusion Modeling Framework offers insightful information and tactical direction for encouraging the acceptance of Kangen Technology pinpointed on water purification. Manufacturers give top priority to developing water ionizers with sustainable attributes that reduce environmental effects over the period of the product's lifecycle, such as energy efficiency and recyclable materials. Many of the organizations are original equipment manufacturer (OEM) based and follow the various ISO standards for better health and sustainability. As per the above analysis, environmental sustainability and product features that follow the ISO standards, influencing the health of consumers and their recommendations, are pivotal in consumer perception for acceptance of water ionizers in society.

Marketing strategies should be embattled to customize and message to various niche market segments and apply adopter classification developed from the modeling framework, including innovator and imitator (including early adopters, early majority, late majority, and laggards). In the later stages, strategies to address the concerns of the late majority and laggards may be necessary. For instance, early marketing efforts should be concentrated on innovators and early adopters who are more sensitive toward new technology and health well-being. There should be a focus on potential customers who are having lifestyle and chronic diseases. Strategies could be refactored in encouraging consumer awareness of water ionizers, their health benefits, and their significance through educational and community activities programs on the need for healthy water and the adoption of water ionizers products for a healthy and longer span of life. The research provides businesses with strategic insights into consumer behavior and adoption patterns. By leveraging this research trend and exploring the consumers' roles as innovators and imitators, an organization can design its marketing strategies to target specific consumer segments in specific regions and enhance the effectiveness of its campaigns to drive sales growth for commercialization and economic growth.

Organizations always have the prospect to improve the sustainability practices of water ionizers, encourage customer for awareness and acceptance, and facilitate the adoption of environmentally conscious and better hydration practices by integrating these managerial implications into their plans and operations. however, businesses are competent enough to predict the future sales trajectory for Kangen water systems while

enabling the Bass model in practice. The overall business strategy involving innovation, inventory management, and production scheduling can all be influenced by these forecasts.

7. Conclusion, Limitations of the Study, and Future Work

COVID-19 pandemic strengthened cognition about health and hygiene, guiding to inflate demand for Electrolysed reduced water (ERW) and is recommended to enhance immunity health. Ionized water is evolving as much as people become aware of its health benefits. With their purported health benefits, ERW signifies the way to improve their overall well-being. The results demonstrate that the external effect is more influential in the North and South regions, and the word-of-mouth effect is more prevalent in the West region. The obtained values of *m, p,* and *q* in all four regions for respective data sets fit reasonably good in the model. It depicts the future roadmap for the intense adoption of water ionizers-based Kangen technology in the Indian market.

Manufacturers and stakeholders anticipate conceivable market growth due to the prevalence of eco-friendly innovative initiatives, the expansion of distribution and supply channels, and technological advancement to improve water quality. The utilization of an Innovation Diffusion Modeling Framework has enriched our vision of the water ionization-based Kangen Technology adoption strategy and provisioned reasonable suggestions for fostering its acceptance and commercial success. Water is everyone's business, so there is still room for more research, even if this study has shed light on the adoption dynamics of Kangen Technology. While the current methodology effectively determines the count of innovators and imitators, The model's equations, parameters and co-efficient e.g. *m, p, q* help in estimating the number of adopters over time, distinguishing between innovators and imitators. It does not explicitly address repeat purchasers. Future research could explore modifications to the Bass Model or alternative approaches to capture repeat purchase behavior, providing a more comprehensive understanding of consumer dynamics. Additional adoption influencing factors, the effect of interventions on adoption rates, long-term adoption trends, and adoption patterns in various markets and other geographies and situations could all be the subject of future research. While the current study focuses on statistical validation of the proposed model for the adoption diffusion of water ionizers in the Indian market, it does not provide evidence of interrelationships among behavioral constructs. Therefore, future research may extend upon validating the identified model with the help of various decision-making techniques like analytical hierarchy process and structural equation modeling to ascertain the intensity of association among critical enablers.

Conflict of Interest

There are no conflicts of interest to declare.

AI Disclosure

The author(s) declare that no assistance is taken from generative AI to write this article.

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