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UNDERSTANDING DIFFUSION PROCESS IN THE CONTEXT OF PRODUCT DIS-ADOPTION

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ПОНИМАНИЕ ПРОЦЕССА ДИФФУЗИИ В РАМКАХ ОТКАЗА ОТ ПРОДУКТА

Diffusion theory is a well-accepted marketing concept that involves regular intervention of customers. But dealing with customers is a staggering task for managers and the challenge becomes stiffer in a dynamic market. It has been seen in the past how (by observing the adoption pattern of individuals) the aforesaid process has helped firms in dealing with innovation adoption. In the present article, we have emphasized the other part of the dichotomy of the adoption process, the dis-adoption, and have thereby formulated a diffusion process incorporating dis-adoption behavior of customers. Moreover, the dependency of imitators on the adoption behavior of innovators regarding the product/service provided by the firm has been highlighted. The proposed sets of models have been categorized on the basis of varying market structure using the exponential and linear market growth functions. Models have been validated and empirically analyzed on two real life sales data sets. Furthermore, a graphical presentation has been shown using ternary plot to see the relationship between the rate of adoption, the rate of dis-adoption and the rate at which new adopters are increasing the market. Our results indicate that the probability of potential discontinuers can be calculated explicitly; we have also discussed the role of previous adopters in contributing to the firm's growth.

DIFFUSION; DIS-ADOPTION; DYNAMIC MARKET; INNOVATION; TERNARY PLOT.

Диффузионная теория является общепринятой в маркетинге, при этом предполагается регулярное вмешательство клиентов в ее рамках. Взаимодействие с клиентами – сложная задача для менеджеров компаний, работающих на динамично развивающемся рынке. Наблюдение за закономерностями, в соответствии с которыми отдельные потребители осваивают инновации, показало роль данного процесса в инновационной деятельности компаний. В данной статье рассмотрена другая сторона процесса освоения – отказ от инноваций и описан диффузионный процесс с учетом поведения потребителей, отказывающихся от использования продукта. Также описано влияние имитаторов на поведение новаторов, осваивающих предоставляемые компанией продукты или услуги. Предложена классификация моделей на основе различной рыночной структуры с использованием экспоненциальной и линейной функций роста рынка. Апробированы и эмпирически проанализированы модели, основанные на двух реальных наборах данных о продажах. Кроме того, построен тернарный график зависимости между скоростью освоения продукта, скоростью отказа от продукта и скоростью, с которой новые потребители, начинающие использовать продукт, увеличивают долю рынка компании. Полученные результаты указывают на то, что вероятность отказа потребителей от использования продукта может быть вычислена в явном виде; описано влияние потребителей, которые уже начали использовать продукт, на экономический рост компании.

ДИФФУЗИЯ; ОТКАЗ ОТ ПРОДУКТА; ДИНАМИЧНО РАЗВИВАЮЩИЙСЯ РЫНОК; ИННОВАЦИЯ; ТЕРНАРНЫЙ ГРАФИК.

1. Introduction. The breadth of the study lies in investigating and understanding the diffusion process of a new product/service. Conde [7] described the diffusion process in a very accurate and lucid manner and stated: Diffusion has to be considered as the propagation of messages related to new ideas that lead to subsequent innovations (products, processes, technology, etc.), with an expectation of change in receptor behavior, which will be evident in adoption or rejection of the innovation. In the early stage of the diffusion process, a small group of population called innovators are initiated to buy the product but later on, the imitators come into existence into the market, which are influenced by the innovators' word of mouth or by other communication channels. A time-lag exists between different consumers of a social system during the adoption period. The social interaction between adopting pioneers and potential adopters explains the phase of rapid market expansion. The satisfied buyers will influence others to make the purchase of the product and also repurchase the product that leads to the expansion of market frequently.

In 1995, Rogers [30] defined the innovation decision as a five-stage process: *knowledge* in which individuals become aware of innovation, *persuasion* which forms the favorable or unfavorable attitude towards innovation, *decision* to accept or reject it, *implementation* to put the innovation in use and at last, *confirmation* to reinforce or reverse their former adoption decision. Out of these five stages, the decision is the most crucial stage where the happening of the sales is dependent upon customers' perception. By drawing attention towards this stage, we have tried to describe the impact of adopters and dis-adopters on the growth of the product/service. Firms know that the success and failure of their new product will shape their future. Therefore, managers are concerned with understanding the sales growth of innovations introduced in the market as well as the factors that shape it. However, there are several aspects that affect the adoption process and that have been examined, including advertising [9, 16, 34], consumer behavior [4,20,35], product warranties [1, 19], product price [1, 6, 29], and word of mouth and social influence [13, 21]. The biggest challenge in marketing research is to study the customers' behavior in all these aspects. Sometimes firms need to change their practice according to the individuals' need and their behavior.

Daron and Joshua [8] investigate the effect of changes in potential market size on entry of new drugs and pharmaceutical innovation, by focusing on exogenous changes driven by demographic pressures. In literature, Romer [31], Grossman and Helpman [14], Aghion and Howitt [2], discussed the role of profit incentives and market size in innovation for the pace of aggregate endogenous technological progress. Lehmann [24] describes the dis-adoption as the process of cessation or substantial reduction in the use of a previously valued behavior or possession. Companies seek to increase their revenue by introducing innovation in dynamic markets. Successful introductions of innovation into the market are beneficial not only from the current customers' perspective but also attract other customers in achieving higher revenues [28]. The reverse case is also true for the real market scenario. If the innovation is not liked by the customers in the market, it would lead to dis-adoption that will ultimately results into lower revenues which in turn slow down the growth of the firm [12, 27]. Parthasarathy & Bhattacherjee [26] examined the service that is perceived as being more useful, easy to use and compatible is more likely to gain wider acceptance among the potential adopters.

Duck [10] described dis-adoption as a process of ending a relationship as separation, termination, dissolution, withdrawal, disengagement, divorce, break-up, discontinuity, decline, exit, and rejection in which each phenomenology is worthy of investigation in its own right. Dis-adoption behavior incurs for the firm losses in the quantitative form (e. g. monetary loss of company) as well as in the qualitative form (e. g. goodwill). In this paper, we have categorized the dis-adopters into two different groups: firstly, the adopters who are not satisfied with the product or have the better option may discontinue using the product. Secondly, the potential adopters who were keenly interested to buy a product, but didn't buy it due to some reason or other, this type of behavior is called balking behavior of the adopters, e. g., a potential adopter of Nokia gets influenced by the salesman to purchase Samsung instead of Nokia. Further, two different categories of the product, tangible and intangible are studied. Tangible products are those which we can see, touch and hear like clothing, whereas the intangible ones are those which cannot be seen and touched like service provided by insurance companies. Some of the researchers [1, 8] had worked by considering tangible product only and some [10, 25] focused on intangible products. We intend to study both types of product.

Dis-adoption holistically is an integral part of the innovation and diffusion process, not a separate process. Moreover, this social process involves not only the individual but rather the whole society. Parthasarathy and Bhattacherjee [26] point out the effective means of customer retention strategies to maintain the market share and revenues of online service firms. They have also analyzed that the negative interpersonal influences generated by disenchanted discontinuers are more persuasive than positive interpersonal influence and lead to overall losses for firms. Some approaches treat adoption as the relationship of marriage between the consumer and the brand and dissolution is visualized as divorce [11]. Dis-adoption has an adverse effect on the firm and may lead it into retrogression. For instance, we can consider the market effects of social networking websites. Since 1994, social networking sites existed in the market, but didn't get much advancement due to limited knowledge available to users. In 2004, a software engineer Orkut Büyükkökten started Orkut [17] as a social networking website with a large number of users, and also in the same year, Mark Zuckerberg, founded Facebook [18] for social networking but with a limited number of users. In later years, the information regarding user-friendly and advanced features of Facebook spread out into the market, which made the users stop using Orkut and start using Facebook, which lead to an increase in the market share of Facebook rapidly. This means that the market penetration is very much dependent upon adopters and their behaviour, as they become the brand ambassador for the innovations.

In this paper, we examine how the market structure affects the whole diffusion process. Market structure as we defined it, refers to the variation in the adoption of product in different state of affairs. The general factors that expressed the detailed knowledge of market structure are: first, product durability and product utility, as more utilization with less durable product/service escorts the exponential growth model (EGM) of market, while the moderate durability and utility leads linear growth model (LGM) of market and more utilization with least durability tends the repeat purchases growth model (RPGM) of marketing. Second, in reality peer pressure occurs in marketing, the adopters which are not potential buyers in actual will buy the product when many of the neighbors/relatives bought the product. Third, variation between the product quality and buyers expectation impinge the market structure, and so on. Hogan et al. [15] shows the impact of a lost customer on the profitability of the firm and also found that the early dis-adopter costs more than the loss of a later adopter. Libai et al. [25] evaluated the influence of dis-adoption on growth in service markets. They presented an approach where they measure the customer equity that takes into account inter-firm dynamics in a growing market and also calculate the customer equity when firms are strongly affected by customer switching to other competitors and dis-adoption of the category.

We use a simple and more powerful technique to define diffusion models where a product is first purchased, after that the information is transferred, and then the changes come in their current market status. Aiming to give models a more direct marketing application, we have leveraged the above impactful dis-adoption in three different market scenarios that may help to improve the accuracy of adoption and dis-adoption predictions. The aim of our research is to contribute to the methodological and substantive evolution of diffusion models towards a better understanding of their application potential. In particular, we consolidate the convenience of using diffusion models to understand the diffusion process of any innovation (consumer products, services, etc.), and extend diffusion models to accommodate effects (such as repeat purchases or dis-adopters) that are not present in many of the existing models.

The objective of our study is to investigate the dis-adoption behavior in different market situations. Our approach is more comprehensive than many studies because we have integrated innovation diffusion modeling with various market structures and have also calculated the dis-adoption rate of users explicitly in each case. We have tested our models on sales data set of two differently used consumers product and services. Their result show that the formulated models gives the better explanatory result of diffusion models and also are two-step ahead forecasts than the basic Bass model [5]. Bass model [5] didn't calculate the dis-adoption rate explicitly and considered the constant market size. Here, in this paper, we have overcome these two limitations of the Bass model.

The rest of the paper has been categorized as follows: the mathematical model formulation has been provided in subsequent section 2. In section 3, verification of the models has been done by analyzing the data. Section 4 comprises the managerial implication and is followed by conclusion in section 5.

2. Model formulation. It will be interesting to note that the spread of diffusion works in the same pattern as an epidemic. In the contagionist paradigm, diffusion comes through personal contact between previous adopters and potential adopters of innovation. It can be termed as the epidemiological model. We can clearly observe that the diffusion model is a rational process as the greater the number of previous adopters, the more information there will be in the market about the characteristics, advantages and previous adopters' experience of the innovation, which reduces the risk aversion of potential adopters and favors the decision to adopt; i. e., the rate of adoption increases with an increase in the number of adopters in the social system. Although there is also the possibility of negative interaction between adopters about the innovation which may lead to loss of the firm, the majority of authors lean towards consideration of positive interpersonal interaction between the population of potential adopters [25]. We outline a simple framework of the diffusion process to structure our research by considering different market structures incorporating dis-adoption among them.

2.1 Proposed modeling framework. In 2009, Libai et al. [25] gave a formulation to estimate the growth of services by considering the dis-adoption rate. They discussed two options to introduce dis-adoption attrition in diffusion models where in the first it defines the lost-for-good dis-adopter who will never rejoin the firm at a later date and in the second category the dis-adopter may rejoin the firm. It depends upon customers' personal experience rather than facts and research whether they rejoin the service or not. To formulate a consistent model Libai et al. [25] assume that dis-adopting customers can rejoin by taking into account the fact that the customer's return is subject to the diffusion process. They also assume that word-of-mouth is exchanged between the users and nonusers. The mathematical model given by Libai et al. [25] to define diffusion pattern with the impact of dis-adopters is as follows:

$$\frac{dN(t)}{dt} = p[m - N(t)] + \\ + \frac{q(1-\delta)N(t)}{m}[m - N(t)] - \delta N(t), \qquad (1)$$

where $N(t) = \int_0^t n(t)dt$ represents the cumulative number of adopters by time t, $n(t)$ is the number of adopters at time t, m defines the expected number of potential adopters, p and q represent the coefficients of innovations and imitations, respectively, and δ is the rate of dis-adoption. In the above-described equation, the first term implies the remaining number of buyers who are influenced by external influence, the second term, $[q(1-\delta)N(t)]/m$, represents the impact of effective word-of-mouth promotion by retained customers, which results in the reduction of imitators by the rate of dis-adoption δ from $[qN(t)]/m$ to $[q(1-\delta)N(t)]/m$ and the third term indicates a decrease in the adopters at a particular point of time, i. e., the group of people who have adopted the product by time 't' who wish to discontinue the product. The impact of the third term can be seen in the second term that represents the effective word of mouth promotion by retained customers. After solving equation (1) with the initial condition $N(0) = 0$, we get the following equation:

$$N(t) = \frac{\bar{m}(1 - e^{-(\bar{p}+\bar{q})t})}{1 + (\bar{q}/\bar{p})e^{-(\bar{p}+\bar{q})t}}, \qquad (2)$$

$$\eta \equiv q(1-\delta) - p - \delta \\ \Delta \equiv \sqrt{\eta^2 + 4q(1-\delta)p} \quad \text{and.} \qquad (3)$$

The parameter $\bar{m} \equiv m\frac{\Delta + \eta}{2q(1-\delta)}$ represents the number of potential adopters incorporating dis-adopters. From equation (3), we can justify that η and Δ have an inverse relation with δ, i. e., the values of η and Δ decrease as δ increases. In variables, $\bar{p} \equiv \frac{\Delta - \eta}{2}$ and $\bar{q} \equiv \frac{\Delta + \eta}{2}$ are constants representing the coefficient of internal and external influence considering dis-adoption attrition respectively. From equation (2), it is clear that the structure of the model is flexible in nature. For different values of $\bar{p}$ and $\bar{q}$, equation (2) can give either exponential curve or S-shaped curve. If the value of $\bar{q} = 0$, then the equation (2) transforms into an exponential growth model. In general, exponential models have been used in case of uniform growth, whereas S-shaped curves have been developed when the growth is non-uniform [21]. The model proposed by Libai et al. [25] was based on the S-shaped growth curve as the innovators and imitators cannot be distinguished due to lack of information, using the similar set of assumptions to incorporate the case of both services and product in the determination of eventual adoptions. In this paper, we propose an alternative way of approaching the model of Libai et al. [25]. In the following sub-section, we assume the rate of adoption to be logistic in nature to define the behavior through which individuals receive information and purchase the product.

2.2 Alternative formulation of the diffusion process incorporating dis-adoption attrition. This methodical approach is based on all the assumptions and situations mentioned above. We have also assumed that adoption by innovators plays an important role as imitators will adopt the product only if innovators purchase it. We propose an alternative methodology for determining the diffusion process. As per the modeling framework provided by Kapur et al. [21] based on the S-shaped curves to derive an alternative formulation of Bass model [5] to incorporate that for a product one can be an innovator or can be an imitator, with the same directions we formulate a model incorporating dis-adoption attrition to define the diffusion pattern. Therefore, the differential equation of the proposed model to calculate the cumulative number of adopters at time 't' is given as:

$$\frac{dN(t)}{dt} = \bar{b}(t)\left[\bar{m} - N(t)\right], \qquad (4)$$

where $N(t)$ is the cumulative number of adopters at time t incorporating dis-adoption; $\bar{b}(t)$ is the rate of adoption considering the impact of dis-adoption.

On considering rate of adoption to follow logistic function., *i. e.*,

$$\bar{b}(t) = \frac{\Delta}{1 + \bar{\beta} e^{-\Delta t}}. \qquad (5)$$

Consequently, equation (4) takes the form:

$$\frac{dN(t)}{dt} = \frac{\Delta}{1 + \bar{\beta} e^{-\Delta t}}\left[\bar{m} - N(t)\right], \qquad (6)$$

here the adoption rate incorporating dis-adoption attrition is defined as Δ; consist of rate of innovators and imitators influenced by dis-adopters in an additive form, i. e. rate of adoption (Δ) = rate of innovators ($\bar{p}$) + rate of imitators ($\bar{q}$). The variable $\bar{\beta}$ represents the learning parameter that defines the shape of the adoption curve taking dis-adoption factor into account. The cumulative sales follow the S-shaped adoption curve $\bar{b}(t)$.

After solving the equation (6) with initial condition $N(0) = 0$, we get

$$N(t) = \bar{m}\left(\frac{1 - e^{-\Delta t}}{1 + \bar{\beta} e^{-\Delta t}}\right). \qquad (7)$$

On considering $\bar{\beta} = \frac{\bar{q}}{\bar{p}}$ and $\Delta = \bar{p} + \bar{q}$, we observe the equations (7) and (2) are identical, which implies that the differential equation (6) is equivalent to differential equation given in Eq. (1) which is an expression to determine the overall sales in the presence of the dis-adoption factor. Here we can see that equation (7) is in same direction as the Bass model [5] but with different parameters (taking into account the rejection/dis-adoption).

2.3 Diffusion patterns with dynamic potential adopter. As discussed earlier, the famous Bass model [5] was based on a certain set of assumptions. The market being fixed in size was one of the prominent assumptions. Many researchers have provided an extension of this perspective [20, 33, 34]. In this approach, fetching the ideas from Kapur et al. [21] and Libai et al. [25] we propose a framework for dynamic potential adopter inculcating the dis-adoption process. And so, the following differential equation has been utilized for the proposal:

$$\frac{dN(t)}{dt} = \frac{\Delta}{1 + \bar{\beta} e^{-\Delta t}}\left[\bar{m}(t) - N(t)\right] \qquad (8)$$

This equation gives the expansion of the above-mentioned diffusion pattern defined by equation (6) by incorporating dynamic market potential adopters $\bar{m}(t)$, instead of $\bar{m}$. There are several factors effective on the social system, which confirms that the population of potential adopters in equation (8) is more pragmatic. The factors like price and quality of the service, promotional efforts made by firms, the socio-economic factors, governments rules and regulations, customer expectations and so on affect the market size on the whole. The important features of equation (8) are: it highlights the market size effect in diffusion process and it determines the probability of dis-adoption of potential buyers. Various modeling approaches have been justified to define the varying pattern of diffusion patterns. One approach has been varying the market size $\bar{m}(t)$ with time that can be linear or exponential. Other approach has been to represent $\bar{m}(t)$ as a function of the number of previous adopters. To study the diffusion pattern we follow the three possible basic changes in the population of potential adopters $\bar{m}(t)$. In Tab. 1 (given in the appendix), we have defined the dynamic potential adopter diffusion models that incorporate the effect of dis-adopters which can be assumed to be the modified form of Kapur et al. [21].

According to the nature of escalation of the product, different forms of $\bar{m}(t)$ have been used. The three general approaches of market size fluctuation for the formulation of diffusion models by incorporating dis-adoption factor are taken into consideration as shown in Table 1. By using these $\bar{m}(t)$ in equation (8) we found the closed form of solution of $N(t)$ using the initial condition $\bar{N}(0) = 0$ implying that initially no adoptions take place. In LGM the rate α is the linear rate of increment in potential buyers with respect to time. While in EGM the rate α is an exponential rate of adoption with time.

Similarly, in RPGM the rate α is the increment of potential buyers with respect to previous buyers, i. e., in this case, the adoption process is dependent upon previous buyers. If the value of δ tends to zero, then the proposed model converges towards the LGM, EGM and RPGM defined by Kapur et al. [21]. Also at the same time the above equations are similar to equation (6), when the rate α at which the market size changes is zero. By considering the value of δ to be non-zero, the value of $\bar{m} < m$, $\bar{p} > p$ and $\bar{q} < q$, also all other parameters will act positively.

3. Data analysis. In order to illustrate the estimation procedure and for generality of diffusion models, we have analyzed Kapur et al. [21] and proposed a model on real sales data-set of two different products/service. DS-I represents the sales data of Nokia cell phones obtained from Anand et al. [3] and DS-II represents the sales data of Ultrasound machines (Jordi.com [37]). The parameters and comparison criteria of the proposed model were estimated using simultaneously NLLS [36] by the SAS software package [32].

3.1 Parameter estimation. The estimates of coefficients of the proposed models and the models given by Kapur et al. [21] for cumulative sales data are given in Table 2 and Table 3 (refer appendix).

Table 2 displays the results of empirical analysis and suggests that the Nokia Cell Phone loses from 7 % to 40 % of their potential customers due to attrition whereas it can be seen from Table 3 that the population of potential adopters of Ultrasound Machines decreases by around 20—30 %. The rate of dis-adoption also varies for each service category DS-I and DS-II. In DS-I, the value of δ varies from 0.005 to 0.1 and for DS-II, the dis-adoption rate lies between 0.12 and 0.16.

Therefore, it is important for firms to study the behavior of customers to make some effective investment in reducing dis-adoption as p is influenced by the external factors of the firms but q is influenced by the word-of-mouth of the actual adopters. The value of q is reduced to $\bar{q}$ because we assume that the only satisfied adopters will spread the positive word-of-mouth.

The ternary plot given in Fig. 1 and Fig. 2 (refer to the appendix) showcases a graphical presentation of three-dimensional parameters in two-dimensional plane. In Fig. 1 and Fig. 2, the x-axis represents the rate of adopters, the y-axis represents the rate of dis-adopters and the z-axis shows the additional adopters of the market potential. By using the ternary plot, we have tried to classify the relation between the rate of adoption (Δ), dis-adoption rate (δ) and the rate at which additional adopters increase the market potential (α) for different market scenarios, by normalizing the parameters to 1. From the ternary graph through Fig. 1, it is discernible that the rate of dis-adoption is always less than 0.2, i. e., we get the upper bound of it in DS-I, on the other hand, in case of DS-II the rate of dis-adoption is bounded between 0.2 and 0.3, which implies that both products are surrounded by a good number of dis-adopters. The other two rates of DS-I show the antipathy relation with each other in order to balance all the three models of DS-I and the parameter α of DS-II influences the market negligibly. So we can conclude that the probability of dis-adoption and adoption affects the whole market of DS-II effectively where rate of adoption is quite high.

3.2 Model comparison. The performance of our proposed models is compared with diffusion models given by Kapur et al. [21]. We have considered the coefficient of correlation R^2 and Sum of Squared Errors (SSE) as goodness of fit measures. R^2 is the square of the correlation coefficient which measures the percentage of the total variation about the mean accounted for the fitted curve. For a larger value of R^2, the model provides the better explanation of the variation in the data [23]. Similarly, SSE defines the sum of the squared differences between the actual value and the predicted value of each observation. The smaller the value of SSE, the better the model fits in the data. The summary statistics of goodness of fit measures for both the models on DS-I and DS-II are shown in Table 4 (given in the appendix). The values of R^2 and SSE give the better fit of our proposed models.

In Fig. 3 and Fig. 4 (refer to the appendix), the actual and the predicted values for both data sets have been illustrated for models proposed by Kapur et al. [21] and for proposed models by using a line graph. All the values of the models are overlapping each other; this means that the proposed models give a good result in all cases.

4. Managerial implications. The presence of so many products and their advertisement has made it convenient for consumers but very difficult for firms. Consumers are directly or indirectly affected by word-of-mouth. And so there is always a lot in the wood that despite being potential buyers, the consumers never make a purchase if they heard anything wrong about the offering. Therefore, we generally judge the success rate of any firm with those of who actually adopt the product. In this work, we have taken care of this fact and provided a mathematical approach for managers by which they can easily determine the number of people adopting/rejecting their product and can hence make a decision to cover up the same. The study is a helping hand to managers in another sense that it simultaneously also takes care of the changing market size scenario, i. e., it provides a good insight into the dynamic aspect of the market.

By knowing the requisites, the firm will be able to understand the endogenous and exogenous factors for dis-adoption and so they can work more intensely to not lose their potential adopters.

5. Conclusions. The proposed work provides an approach to alternatively determining the actual number of adopters when market expansion and dis-adoption are happening simultaneously. The study investigates the diffusion process when the behavior of early innovators affects the entire adoption process; as their positive and negative word-of-mouth influence the imitators to a very good extent. Here, taking the idea from an established model by Kapur et al. [21], we have proposed three different approaches for market expansion.

All the parameters affected by the dis-adopters and the rate of dis-adopters have been calculated separately. Three different dynamic market potentials have been considered to give a better explanation of the unstable market size. Our study investigates the rate of entry and exit of the adopters into the market by taking different market scenarios, for example, in case of DS I, the proposed exponential growth model with a 3 % exponential increment in the potential adopters with time will lead to an approximately 1 % dis-adoption among the adopters.

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