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SIMULTANEOUS COMPETITOR AND CUSTOMER DIFFUSION:

A MARKET GROWTH MODEL BASED ON MARKET SPACE

AND COMPETITION

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ABSTRACT

This paper adds addresses the interaction between competitive dynamics and market evolution. Specifically, it focuses on the development of the market of a new product, in terms of customer adoption as well as competitive entry. The objective of this paper is to develop a model for the growth stage of a new market that addresses the supplier and customer diffusion process and the interaction between them.

The contribution of our approach is threefold: (i) the development of a competitor diffusion model, (ii) the combination of a competitor diffusion model with a customer diffusion model, recognizing the interplay between competitive entry and market-level diffusion, and (iii) the recognition that competitive entry effects in the diffusion model are endogenous, resulting from the entry decisions of firms.

INTRODUCTION

Market entry is a subject that has received considerable interest from researchers in marketing, strategy and economics. Entry plays a key role in economic models of industry evolution (Cabral, 1993; Eatin and Ware, 1987; Klepper and Graddy, 1990; Klepper and Miller, 1995). As a cornerstone of market structure, the number of competitors in an industry is central to the resulting profitability of participants. Conversely, treating entry as endogenous, competitive entry occurs until expected profits are driven to zero. Previous research in economics has treated demand as an exogenous and stable given, and neglected the role that competition plays in developing demand. This paper adds to the recent increasing interest in research that addresses the interaction between competitive dynamics and market evolution (Gatignon and Soberman, 2000). Specifically, it focuses on the development of the market of a new product, in terms of customer adoption as well as competitive entry. By that, we provide a link between the new product diffusion and market entry literature.

New product diffusion is a subject that has been extensively studied by researchers in marketing. Previous research has dealt with the development of a customer diffusion model that portrays the process of adoption of a new product by a customer population. Innovation diffusion models typically only consider the demand side and do not include supply side effects. By doing that, existing research ignores how supply-side competitive actions change the diffusion process. There exists a vast amount of research on demand-side diffusion models. These studies either look at the aggregate rate at which new products penetrate a population of potential buyers, or consider the antecedents of innovation adoption and the adoption process at an individual consumer level. However, the mirrored supply-side has been largely ignored (Lambkin and Day, 1989). Managers are increasingly interested in how their actions contribute to the development and evolution of a market. Diffusion theory is quite incomplete unless it recognizes the proactive nature of these actions (Robertson and Gatignon, 1986).

The decision to enter a new market is obviously guided by the expected size and profitability of the market. However, neither are well-established facts in the early stages of an innovation's market development. The size of the market is suspect to debate because consumer acceptance of an innovation is uncertain. The market's profitability depends on the competition between companies. On the other hand, this competition may create a more attractive proposition for customers, leading to an enhanced product acceptance and diffusion. This suggests that increased competitive presence may actually increase the market's attractiveness because it stimulates demand. This increased demand in turn enhances new entry of new competitors. Clearly, the growth of the market is a simultaneous dynamic process, integrating diffusion of demand and supply. The competitor diffusion model expresses the increase in the number of competitors in a new market over time. The customer diffusion model expresses the increase in customer adoption of a new product over time.

The objective of this paper is to develop a model for the growth stage of a new market that addresses the supplier and customer diffusion process and the interaction between them. Diffusion research has almost exclusively focused on customers, ignoring the role that the presence of competitors plays. This paper represents an initial attempt to model the demand and supply side that constitute the development and growth of a new market. In doing so, it is important to realize that entry of new competitors is treated as endogenous to the new product diffusion. Alternatively, new product diffusion results partly from the development in the number of competitors offering the new product. Hence, we model structural equations at the market level, representing supply and demand diffusion.

The contribution of our approach is threefold: (i) the development of a competitor diffusion model, (ii) the combination of a competitor diffusion model with a customer diffusion model, recognizing the interplay between competitive entry and market-level diffusion, and (iii) the recognition that competitive entry effects in the diffusion model are endogenous, resulting from the entry decisions of firms. To accomplish this, we develop a model for the pattern of competitive entry over time that incorporates effects of market diffusion as well as previous entry dynamics. Second, we assess the impact of competitive entry on market-level diffusion.

The balance of the paper is organized as follows. First, the model development for the supply- and demand-side diffusion is discussed. Next, we discuss the application of the model to empirical data and conclude with a discussion of the contribution and limitations of the study.

MODEL DEVELOPMENT

We are interested in capturing the rate of entry of competitors in a new market at time t, denoted by n(t), as a function of the entry dynamics until t, as well as the sales evolution until then. Likewise, the sales at time t, denoted by s(t), are modeled as a function of previous sales, as well as competitive entry effects. The general representation of our model thus consists of a simultaneous customer and competitor diffusion equation.

$$\begin{cases} s(t) = \dfrac{dS(t)}{dt} = f(n(t), N(t), S(t)) \\ n(t) = \dfrac{dN(t)}{dt} = g(N(t), s(t), S(t)) \end{cases}$$

Given the already extensive existing literature on customer diffusion models, the competitor diffusion equation receives the most emphasis in the remainder of the paper and is most extensively discussed. The customer diffusion equation will be largely based on the well-established Bass-diffusion model (Bass, 1969). The model will be adapted to incorporate the effect of competitive diffusion. The competitor diffusion equation is not grounded within existing models. The functional form and theoretical foundation for it are presented in the following section.

COMPETITOR DIFFUSION EQUATION

In contrast to the attention that customer diffusion received, competitive diffusion is a largely ignored issue in marketing research. The competitor diffusion model depicts the number of competitors that enter a new market over a period of time. It is an aggregate model of entry timing of the individual competitors. Some studies, mostly outside the marketing literature, have addressed the rate of entry in a new market. These competitor diffusion models mostly treat it as a self-contained process, and do not incorporate market evolution characteristics.

Population ecology theory provides a supply-side theory of market evolution that takes into account the evolution in competitive intensity (Lambkin and Day, 1989). The model specifies the process at which the population of suppliers grows proportionally to the difference between the present population size and the equilibrium level population size (Hannan and Freeman, 1977). This equilibrium level can be interpreted as the 'carrying capacity' of the market. The most popular form of this model uses a logistic growth curve that is identical to the well-known Bass-diffusion model if the innovation effect is set to zero. According to this model, the rate of entry of new competitors is related to the current number of entrants. Similar to innovation sales diffusion models, Bridges et al. (1992, 1993) use similar models but combine innovative and imitative forces to forecast the number of competing products in an industry.

In the same research tradition, density-dependence models have been developed (Hannan et al., 1995; Hannan, 1997; Ranger-Moore et al., 1991). The basis of these models is the idea that increased population density initially increases a population's legitimation and therefore has a positive effect on the entry rate. Increased density however also generates intensified competition, which has a negative effect on founding rates. This competition effect corresponds to the ecological hypothesis of saturation of the existing resource base. The resulting entry rate is assumed to be proportional to the legitimation effect and inversely proportional to the competition effect.

The competitor diffusion equation that is developed in this paper starts from an individual perspective and then builds up to an aggregate model. The question addressed by the model is, given a population of potential entrants, what determines the rate or entry over time. To go from the individual model to the aggregate model, we implicitly assume that the attributes of individual firms (such as innovativeness, resources, the existence of transferable assets, etc.) are randomly distributed and do not systematically change over time. These individual differences may be relevant to explain which firm enters at a specific point in time, but can be disregarded when looking at the total entry probability of the entire population. This permits us to view the entry time as drawn from a homogenous population.

The individual-level adoption model is based on a stochastic exponential process. The probability that entry will occur in a time interval [0,t] for any member of the population is exponential with parameter h. The expected time to entry is thus 1/h.

The cumulative distribution F(t) for the event that an organization will enter by time t is equal to:

$$F(t) = 1 - e^{-ht}$$

And the probability distribution f(t):

$$f(t) = he^{-ht}$$

The hazard of entry, which is the transition probability in a time interval [t, t+dt], given that an organization has not entered, is equal to the parameter h. As will be specified below, h is a non-stationary parameter that is modeled as a time-varying function, based on a utility framework.

$$h(t) = \frac{f(t)}{1 - F(t)} = \frac{he^{-ht}}{e^{-ht}}$$

The transition from the individual-level model to the aggregate model is based on the assumption that the unordered points of time at which each company enters are randomly and identically distributed. The cumulative number of entrants by time t then can be characterized by a binomial distribution with parameters N* and F(t). N* is the population of potential entrants from which entrants at a given time are drawn. The choice facing each population member is binary, and the number of entrants is thus the expected value of a binomial distribution with a probability F(t).

N(t) ~ Binomial (N*,p) where p=F(t)

N* is the total number of potential entrants and N(t) is the cumulative number that has entered at time t.

The expected cumulative number of entrants is then the expected value of this binomial distribution:

$$E(N(t)) = N = N^*.F(t) = N^*.(1-e^{-ht})$$

The expected rate of entry n(t) can be expressed as:

$$n(t) = \frac{\partial}{\partial t}(E(N(t))) = h(t).N^*.e^{-ht} = h(t)(N^* - N(t))$$

The individual stochastic process thus results in the intuitively logical aggregate process that expresses the rate of entry as the product of the hazard of entry and the number of potential entrants that has not yet entered. The hazard of entry at time t is expressed as a function of entry and sales dynamics until time t. The functional form for this hazard is based upon utility theory. Utility theory describes decisions as a result of a utility-optimizing behavior and results in a discrete choice model with a binary dependent variable that expresses the probability of an event. Using the logistic form, the probability that a company i enters at time t, given that it has not entered before, is:

$$h(t) = p(entry) = p(u_{i,t} > 0) = \frac{1}{1+e^{-u_t}}$$

For time-dependent utility this is equivalent to a hazard model and the competitor diffusion model can be expressed as:

$$n(t) = \frac{1}{1+e^{-u_t}}(N^* - N(t))$$

Now, we need to determine an expression for the time-dependent utility of entry. We assume an additive utility model that incorporates three effects: a demonstration effect, a market space effect and an effect resulting from expected asymmetric competition due to experience advantages of previous entrants. These three effects are represented in the following equation for the utility of entry at time t, and are discussed in the following paragraphs.

$$u_t = \beta_1 + \beta_2 C(t) + \beta_3 \frac{s(t)}{C(t)} - \beta_4 A_C(t)$$

C(t) is the cumulative number of competitors present at time t. s(t) the sales in period t. A_C(t) represents the experience advantage effect at time t.

Demonstration Effect

It has been shown that the existence of prior entrants increases the market's attractiveness for followers by banking on the ‘free-rider' effect (Shankar et al, 1999). Competitor diffusion has a positive effect on the growth of later entrants, implying an advantage for entry in the growth stage of a market instead of pioneering the market. Competitor diffusion can thus be interpreted as a positive feature that encourages following entrants.

Besides, it can be difficult to assess the potential of a new market. Expected future profits cannot be derived from past data and demand forecasts can show a great deal of variance. A company considering entry therefore has to rely on premature market signals. The adoption from other organizations contains signal value about the benefit of adoption because it increases the perception of market attractiveness. This positive effect of the number of preceding entrants has been mentioned in both economics and organizational behavior.

Economists refer to the "demonstration effect" as the positive effect of successful experience of others on the profit perceptions associated with entry. Gort and

Konokayama (1982) empirically show that competitor diffusion has a high explanatory power in predicting entry rates.

Organizational theory provides theoretical and empirical evidence that companies engage in practices that are adopted by a large number of other organizations, even without the manifestation of positive experiences. Two forces can provide the foundation for this process (DiMaggio and Powell, 1983). First, coercive isomorphism results from formal or informal pressures from outside agents that influence an organization's behavior. In the case of a new market created by an innovation, the pressure from outside stakeholders on incumbents not to forego the opportunity can be considerable. Second, mimetic isomorphism results from the ambiguity that is present in a high-uncertainty situation (Haveman, 1993). To deal with this, organizations follow the footsteps of others and model themselves likewise. Especially in contexts of high uncertainty, as is the case at the initial stages of an innovation's market development, this frequency-based imitation prevails (Haunschild and Miner, 1997). Because of the uncertainty associated with potential outcomes, imitation of other organizations happens even without evidence of success. The mere fact that several other firms took the same action induces its legitimacy. This legitimation effect is prevalent in density-dependence models for organizational entry (Hannan et al., 1995; Hannan, 1997; Ranger-Moore et al., 1991).

Market space effect

The market space effect expresses the amount of resources (e.g. customers) competitors compete for. The utility of entry into a new market increases with the market potential, which is expressed in terms of the size of the market (Chappell et al, 1992). The entry rate should therefore increase with sales. This is however moderated by the expectation of competition (Lilien and Yoon, 1990). Whereas the presence of other competitors may signal an attractive market at first, as the number of competitors soars it becomes less appealing. The size of the available market has to be moderated for the crowdedness of the competition for these resources. Ecological models assume that the entry rate and equilibrium state of a population is determined by this resource dependence between competitors. Nevertheless, they do not explicitly take into account the dynamic character of this resource base and the underlying assumption is thus that the amount of resources available is predetermined and remains constant. Likewise, economic models of entry generally treat demand as a stable and exogenous factor. In our paper, the supply-side model is addressed simultaneously with the demand-side model. This implies that demand is treated as a time-dependent state and the evolution of the market size is taken into account. The market space effect is thus expressed as proportional to the size of the market at time t, and inversely proportional to the number of competitors among which this market is divided.

Experience Advantage Effect

The probability of entry depends not only on the perception of profit opportunities and associated risks, but also on the advantage of potential entrants relative to existing firms in the market. The market space effect implicitly assumes that every firm has the same capability to capture an even share of the market and thus treats the population as homogenous. We want to include the effect that over time resources get heterogeneously distributed and entry barriers increase, because existing organizations get institutionalized and have the ability to develop a learning curve.

Gort and Konakayama (1982) point to the accumulation of intangible capital that helps incumbents to be more effective competitors. As the stock of built-up capital of presiding firms increases, entry barriers are created because these firms develop an advantage over new entrants. Accumulated intangible capital is related to the time that existing firms had to build it up. As a consequence, companies tend to assume a bigger share of the market as they age (Dunne et al, 1988). This phenomenon is referred to as the strong-survivor hypothesis (Barnett, 1997). It indicates that organizations become more fit and stronger competitors over time. These experience advantages of previous entrants influence the incentives for other companies to enter the market (Cabral, 1993).

It has been argued that experience advantages are related to the time since emergence of the new market and to the entry pattern since then (Cabral, 1993; Gort and Konokayama ,1982). This means that competitors should be weighed by their age in the market. We argue that the the advantages of previous entrants depend on the market development. This means that entrants should not be weighed by the time since entry, but by the realized customer diffusion since entry. The average experience of incumbents at time t can then be expressed as:

$$E_N(t) = \frac{\sum_{s=1}^{t} n(s)(S(t) - S(s-1))}{N(t)}$$

The competitive effect that arises from previous entrants should be corrected for the evolution in experience advantages of these incumbent competitors. The effect of the presence of previous entrants is thus moderated by their history in the market. Over time, the competition in the market is thus enhanced by an increase in experience. An increase in average experience shifts the competitive effect up. The experience advantage effect can thus be expressed as:

$$A_C(t) = \frac{\Delta E_N(t)}{E_N(t-1)} C(t)$$

CUSTOMER DIFFUSION EQUATION

The customer diffusion equation is based on the well-known Bass diffusion model (Bass, 1969). The underlying premise of the model is that the conditional probability of adoption from a potential adopter at time t, depends on two forces. One force depends on the proportion of potential adopters that has already adopted. This is the imitation effect. The other force captures the probability of adoption that is independent of social contagion. This is the innovation effect.

$$s(t) = \frac{\partial S(t)}{\partial t} = \left[\alpha_1^* + \frac{\alpha_2^* S(t)}{M}\right][M - S(t)]$$

M is the maximum number of adopters, S(t) the cumulative sales until time t. α_1* is called the coefficient of innovation and α_1* is the coefficient of imitation.

This model is adapted to include the supply-side effects. Supply-side diffusion is supposed to have feedback effects on the demand-side diffusion (Lambkin and Day, 1989). Demand can be accelerated by an increase in the number of competing firms (Kim et al., 1999; Mahajan et al, 1993; Krishnan et al., 2000) It not only increases the number of options to customers, but also increases the competition in the market, leading to better prices, aggressive promotion and pressure to perform in terms of customer satisfaction.

A new entrant may influence two elements of the diffusion curve: the total market potential and the diffusion speed (Krishnan et al., 2000). To incorporate the market potential effect into the model, the same specification as Kim et al. (1999) is used. It identifies the total market potential as $M(1\text{-}\exp(-\alpha_3 C(t))$. This specification has the nice property of increasing to the asymptotic maximum value of M as the number of competitors increases.

We expect that new entrants will primarily affect diffusion speed through the innovation effect and not the imitation effect. The introduction of a new entrant creates an extra stimulus for adoption that occurs through sources independent from the social system and thus should be represented in the innovation effect. On the other hand, the behavioral process that induces the imitation effect is not expected to be influenced by the launch of new entrants. This means that when new competitors enter, this does not stimulate this contagion process but has a direct effect on diffusion acceleration. The innovation coefficient is therefore hypothesized to be related to the number of new entrants on the market. The argument behind this choice is the idea that the launch of a new entrant enhances adoption that is caused outside imitation effects and thus should be represented in the innovation effect. The effect of new entrants is not expected to be mediated by social contagion processes. Previous adopters advocate their supplier and thus primarily affect the adoption of existing brands (Parker and Gatignon, 1994; Mahajan et al, 1993). New entrants thus can only have a direct effect on the speed of diffusion. The innovation effect represents adoptions that occur as a result from mass media communications (Bass, 1969). The entry of new competitors is expected to enhance this effect because launch efforts of the new entrants boost the adoption resulting from mass media communications.

Concluding this discussion of the competitor and customer diffusion equations, the proposed supply- and demand-side growth model thus has the following form:

$$s(t) = \frac{\partial S(t)}{\partial t} = \left[\alpha_1 n(t) + \frac{\alpha_2 S(t)}{M(1 - e^{-\alpha_3 C(t)})} \right] \left[M(1 - e^{-\alpha_3 C(t)}) - S(t) \right]$$

$$\text{with: } n(t) = \frac{1}{1 + e^{-\beta_1 - \beta_2 C(t) - \beta_3 \frac{s(t)}{C(t)} + \beta_4 A_C(t)}} (N^* - N(t))$$

EMPIRICAL TESTING

Data

To estimate the proposed model, we need data on sales and entry for a new market over a period of time. This time period must stretch from the initial periods of product diffusion. We use data on the online brokerage market. Data collection happened through an extensive search of published data on online brokers. This led to a database of current online-brokers and previous entrants that had exited, a total of more than 170 entries. For each of these individually, the entry-date was identified. Sales data were retrieved from market research and investment reports. The resulting data encompass quarterly data on sales and entry for 1996-2000[1].

The measure for sales should reflect the penetration level of online brokerage in the market, and should be resistant to fluctuations in trading volumes. Sales were therefore identified in terms of the number of online-brokerage accounts, which is a good measure for customer adoption. It reflects the extent to which customers accept online brokerage. It also incorporates a long-term vision on expected revenues. Because an account generates revenues throughout its lifetime, the number of existing accounts is a good measure for market size. The cumulative number of accounts will therefore be used in the market space term of the competitor diffusion model. For the customer adoption equation, an exogenously specified ceiling for the total market potential is used. The long-run market potential for on-line brokerage account is set to be equal to the total number of regular, off-line brokerage accounts in the market, which is 80 million.

Because we model the growth stages of a new market, firm exits are not prevalent. They are however taken into account to calculate the total number of competitors in each time period, but no formal exit model will be developed and estimated.

ESTIMATION

The model consists of a system of two nonlinear equations. The estimation method must recognize the interaction between the competitor and customer diffusion equations. In the model estimation, it is important to recognize that firm entry decisions are endogenous on the market conditions, as displayed by the competitive diffusion equation. The applied estimation method bears on three-stage least squares principles, and explicitly makes entry endogenous. The estimation proceeded by first estimating the competitive diffusion equation with predetermined covariates. The retained fitted values for the competitive entry rates are used in the customer diffusion equation. Competitor entry is thus made endogenous in the customer diffusion equation. The customer and competitor diffusion equations are estimated simultaneously by applying nonlinear seemingly unrelated regression with Gauss-Newton optimization.

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[1] Details about the data collection process are not included in this paper, but are available from the author.

RESULTS

Overall Model Performance

Figure 1 graphically displays the predicted and actual data for the cumulative number of entries over time. The results provide strong support for the proposed model because the predicted pattern follows the dynamics of competitive diffusion closely. The cumulative entry curve shows a consistently increasing pattern, with two acceleration points. These accelerations can also be recognized in the predicted entry curve.

Figure 2 represents the estimation of the customer adoption curve. The customer diffusion model of the new products also demonstrates a very close fit.

Insert Figure 1 & 2 About Here

Coefficient Estimates

Table 1 provides parameter estimates for the proposed model. The model is formulated such that the expected value of each parameter is a positive number, except for the utility intercept term β_1 for which no specific sign is expected.

Insert Table 1 About Here

We find support for the hypothesis that competitor diffusion increases the market potential. The effect of competitor diffusion on the innovation coefficient of the customer diffusion equation is not confirmed. The estimated coefficient is not significant.

The model estimates show no support for the demonstration effect on competitor diffusion. This may be due to the fact that this effect is only significant in the initial stages of the market, when entry is a signal of market potential and functions as an uncertainty-reducer.

The market space effect is confirmed. If the market becomes too crowded to sustain a sufficient level of resources, entry becomes less attractive. This is in line with the density-dependence theory. If the market grows faster than the number of competitors, this creates new space for entrants. The experience advantage effect is also significant. This result shows that the market may show entry saturation earlier than would be expected if competition is assumed to be symmetric.

These results demonstrate that the rate of entry is determined by the balance between market space and the competition over it. Market space is created if the market grows faster than the number of competitors does. This creates a positive effect on entry. However, this effect can be diminished by the strength of existing competitors, which reduces incentives to enter. The experience advantage effect expresses the extent to which newly created market space is likely to go to strong incumbents. It thus expresses the extent to which competition is not homogenous. If the competition does not increase in line with the market, this creates an opening for new entrants. Inspection of these two major effects of market space versus experience advantage explains the two stages in the competitive diffusion curve at which entry accelerates. The first acceleration of the entry rate is due to an absence of strong competition, combined with a growing market. The second acceleration of entry happens simultaneously with an acceleration of customer diffusion that exceeds the negative competition effect.

Comparison with individual entry and sales models

To fully assess the performance of the model in estimating the entry- and sales-dynamics of a new market, it needs to be benchmarked against existing models. The incorporation of competitive diffusion with the sales diffusion model and vice versa is one of the major contributions of this paper. To our knowledge, only one existing model in the marketing literature addresses the interplay between the two models and estimates them together (Kim et al., 1999). The model developed by Kim et al. is thus a natural benchmark for the proposed model.

The Kim-model uses an equation that is reminiscent of the Bass-diffusion model to estimate sales, and incorporates effects for the number of competitors in the market. The only difference with our model is that the innovation-effect is expected to be linearly related to the number of competitors, whereas our model claims this to be linked to the number of new entries. The effect of the number of competitors on the market potential has the same specification. The competitive diffusion equation in the Kim-model assumes that the number of entries is a linear function of sales and the number of competitors.

$$\frac{dS(t)}{dt} = \left[\alpha_1 C(t) + \frac{\alpha_2 S(t)}{M(1-e^{-\alpha_3 C(t)})}\right] . \left[M(1-e^{-\alpha_3 C(t)}) - S(t)\right]$$

$$\frac{dN(t)}{dt} = \beta_1 \frac{dS(t)}{dt} + \beta_2 C(t)$$

Other models for competitive diffusion disregard the simultaneous market development process and treat it as a self-contained, independent system. A common parametric specification of the model of ecological competition is the generalized Yule-model (Hannan, 1997).

$$\frac{dN(t)}{dt} = \beta_1 C(t)^{\beta_2} \exp(\beta_3 C(t)^2)$$

Other studies use a log-quadratic model (Hannan et al, 1995).

$$\frac{dN(t)}{dt} = \beta_1 \exp(\beta_2 C(t) + \beta_3 C(t)^2)$$

The fit of the proposed model to estimate competitive diffusion is compared with the Kim-model, Generalized Yule-model and Log-quadratic model. Table 2 reports key fit-measures for each model. The proposed model performs consistently better.

Insert Table 2 About Here

The predictions of the different models are graphically compared in Figure 3. As expected, the Generalized Yule model and Log-quadratic model perform similarly. The Kim-model fails to recognize the peaks in competitive entry. The figure demonstrates that although our model sacrifices more degrees of freedom than the other models, it is able to capture the dynamics of the competitive diffusion process better. Therefore, our model not only demonstrates a better fit with actual data, it also contributes in a better understanding of the driving forces of competitive entry dynamics. Whereas other models predict a continuous increase in the number of entries, followed by a continuing decline, the proposed model exposes the peaks of entry, and the following lows.

Insert Figure 3 About Here

Table 3 presents a comparison of the customer diffusion equation of the proposed model with the Kim-model and the Bass model, which does not incorporate entry effects.

Insert Table 3 and Figure 4 About here

CROSS-SAMPLE VALIDATION

The validity of the model is demonstrated further by applying it to a different context. We use the data reported by Kim et al. (1999) on the pc-market. The limited number of data-points limits the degrees of freedom, but estimating the model on this other sample still provides an indication about the model's cross-sample validation. It also hints at the generalizability of the model by applying it to a totally different context. Other than the original dataset from a service innovation context, the pc-data are from a manufacturing context.

Table 4 contains a comparison of the overall model performance with Kim et al.'s model. The proposed model consistently performs better. The biggest difference can be seen in the supplier model fit. The customer diffusion models only differ in terms of the proposed innovation coefficient, so it is not surprising that the differences are relatively minor.

Insert Table 4 About Here

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FIGURE 1

Cumulative Number of Entries

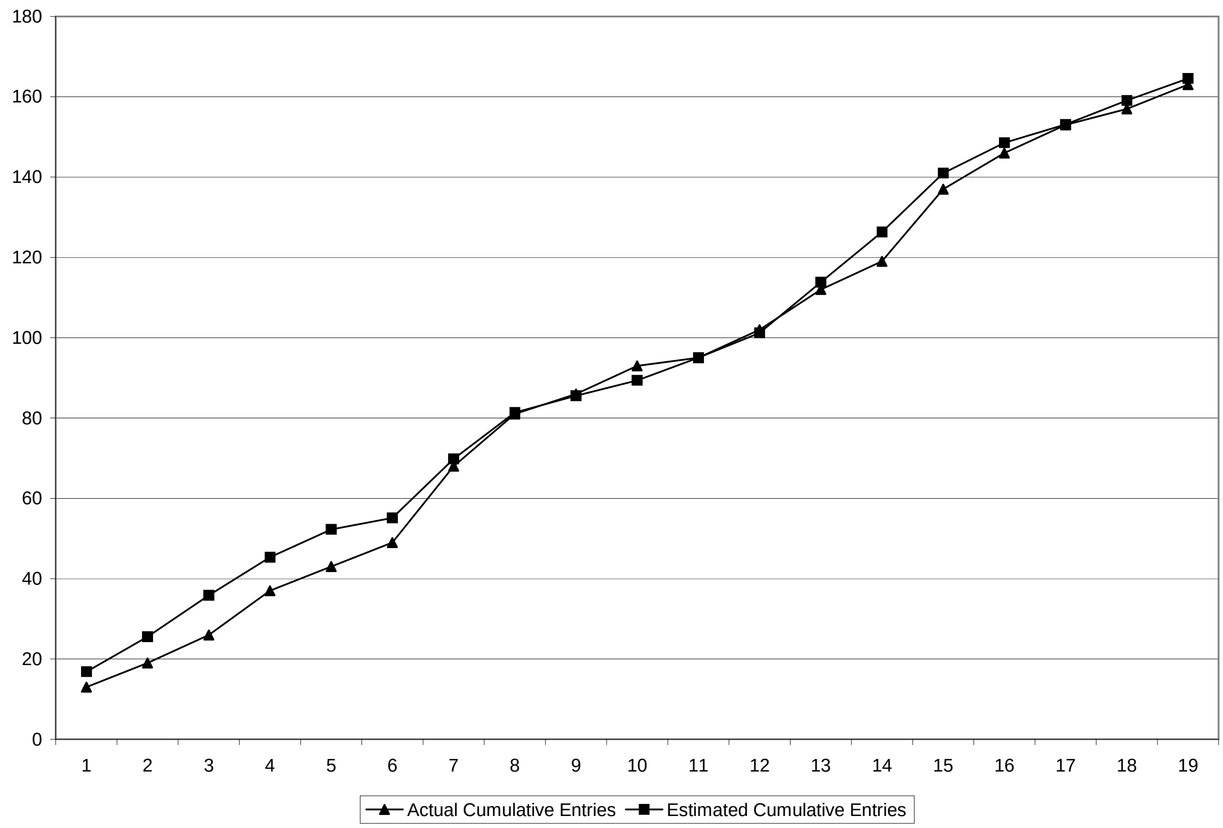


FIGURE 2

Cumulative Sales

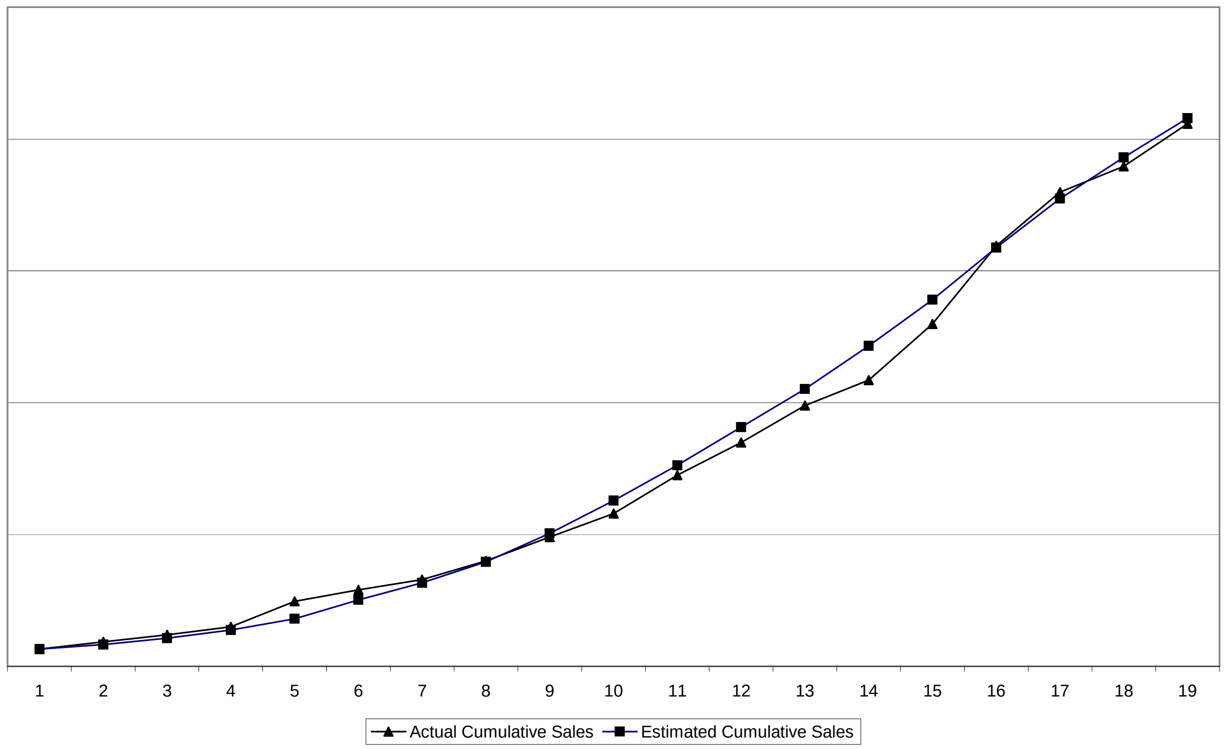


TABLE 1

Parameter estimates

	Estimate	t-value
α_1	- 0.00203	- 0.50
α_2	0.4190**	3.74
α_3	0.0026**	9.99
β_1	4.1916**	9.22
β_2	-0.0008	-0.10
β_3	0.0367**	3.06
β_4	0.0431**	3.02
N*	165.51**	32.88

** : $p < 0.01$

TABLE 2

Estimated competitive diffusion comparison on Root-Mean-Square-Error and Mean Absolute Deviation

	RMSE	MAD
Proposed model	3.259	2.665
Kim-model[2]	5.474	3.497
Generalized Yule model	4.497	3.103
Log-quadratic model	4.5462	3.247

[2] Because the Kim-model is introduced as a simultaneous equation model, the entry- and sales-diffusion equation are estimated simultaneously with SUR

FIGURE 3

Number of entries

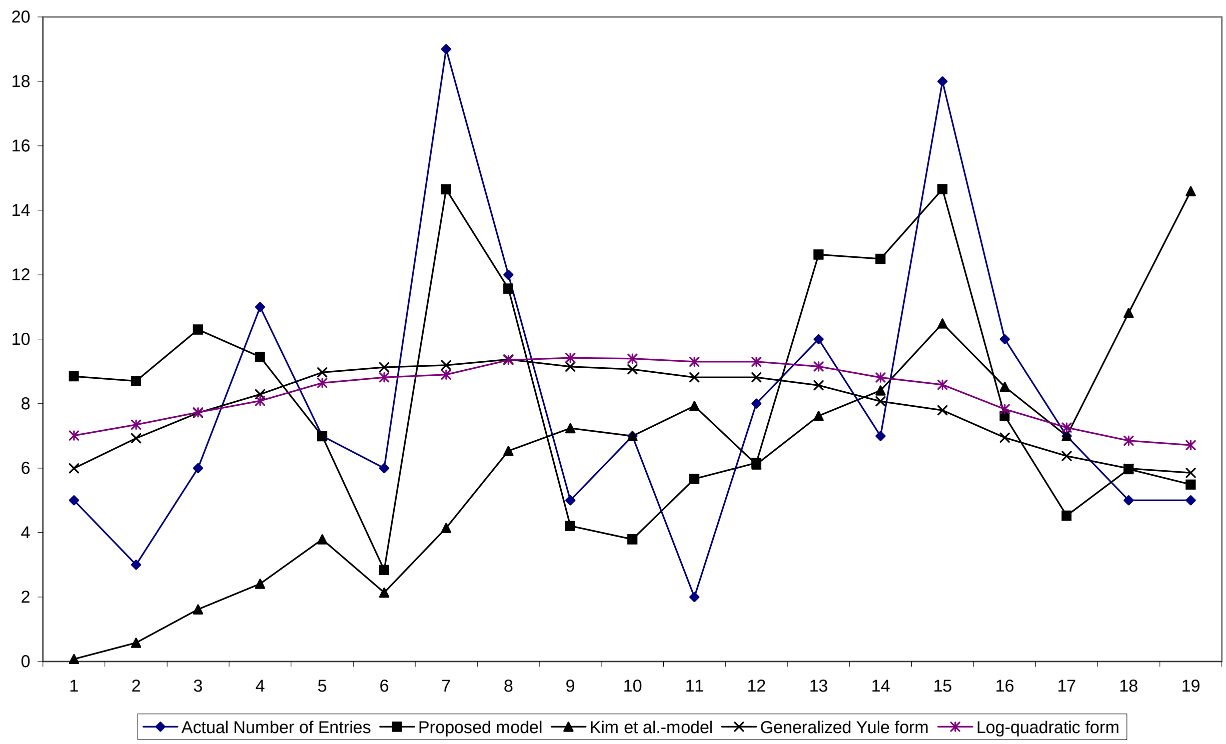


TABLE 3

Estimated sales diffusion comparison

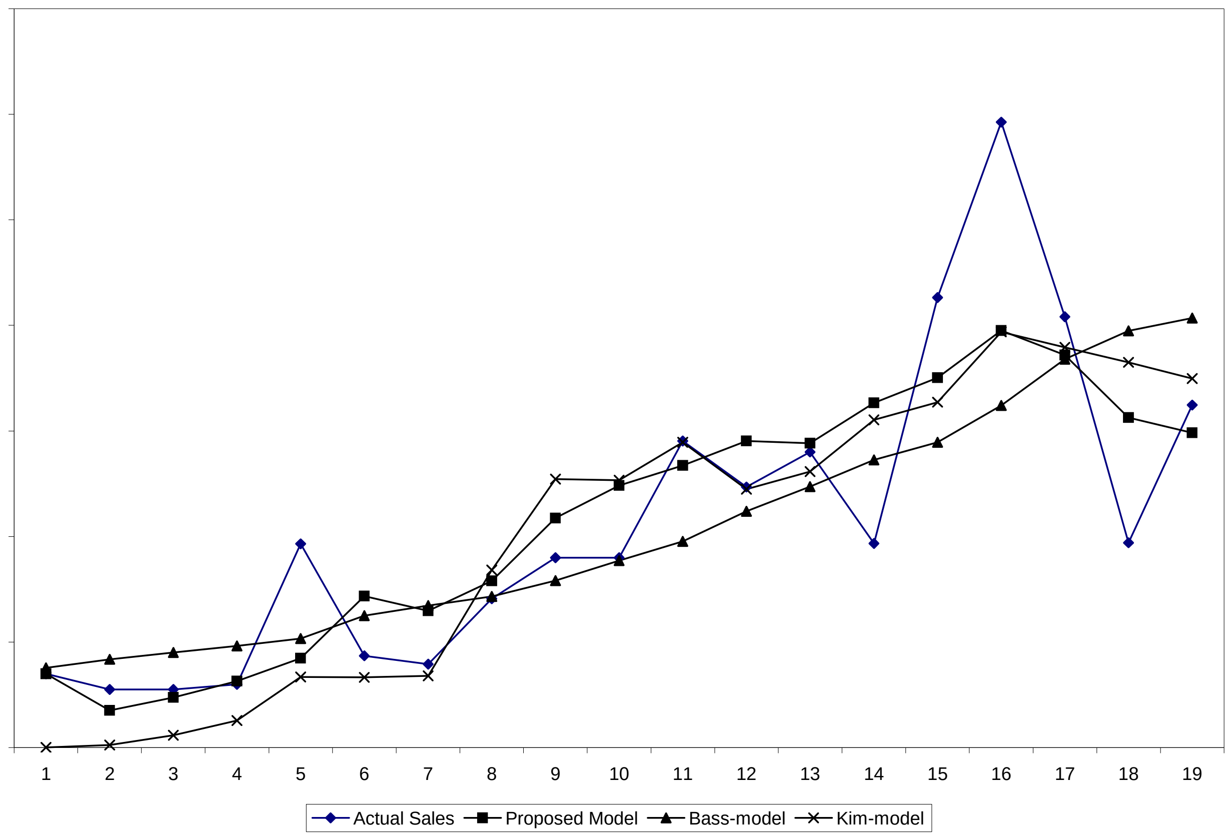
	α_1	α_2	α_3	RMSE	MAD
Proposed model	- 0.00203	0.4190**	0.00263**	419.2	271.5
Kim-model	0.00147	- 0.0862	0.00367*	455.6	314.4
Bass-model	0.00483*	0.12257**	0	502.7	335.6

* : $p < 0.05$

** : $p < 0.01$

Sales measured in number of accounts (1000)

FIGURE 4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Actual Sales
Proposed Model
Bass-model
Kim-model

TABLE 4

Root Mean Squared Error of model predictions

	Online Broker		**PC**	
Proposed Model				
	RMSE	MAD	RMSE	MAD
Customer diffusion model	419.2	271.5	0.853	3.32
Competitor diffusion model	3.259	2.665	1.896	1.49
Kim-model				
Customer diffusion model	455.6	314.4	0.798	3.28
Competitor diffusion model	5.474	3.497	5.595	3.22