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The diffusion of mobile social networking: Further study

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ABSTRACT

In a recent study, Scaglione et al. (2015) analyzed the diffusion of mobile social networking in four G7 countries. Using Bass's model and Bemmaor's Gamma/Shifted Gompertz (G/SG) model, they found evidence of a left skew in the right-censored distributions of the times to adoption in three countries out of four. However, this conclusion relied on the skewness parameter of Bemmaor's model. We reanalyze the data, making use of three special cases of the G/SG as well as the full version. Extending the data set to six countries, we show that (i) fitting the four models to the data does not allow us to discriminate between models, but (ii) forecasting the subsequent adoptions provides a strong support of right skewness in the data set: each country (except France) shows a substantial mass of later adopters of mobile social networking following an initial embrace of the access.

"... It is thus of interest to understand how attention to novel items propagates and eventually fades among large populations."

(Wu & Huberman, 2007)

1. Introduction

A recent study by Scaglione, Giovannetti, and Hamoudia (hereafter SGH, 2015) focused on the diffusion of mobile social networking (MSN) in four G7 countries. Using both Bass's (1969) model and Bemmaor's (1994) Gamma/Shifted Gompertz model (G/SG) on 67 monthly data points, they found that the adoption curves were left-skewed in three countries, with France being the exception (no skew). This pattern represents an apparently increasing fervour for social media at an *increasing* rate as the pool of active, unique MSN users increases (for France, the rate of change is constant). However, their finding is based on the fit of the more flexible model (the Bemmaor model) to the data when the special case (the Bass model) provides an equal fit. We reanalyse their data by (i) including a broader range of models, and (ii) relying on the forecasting accuracy for assessing the skew of the right-censored diffusion curves. Similarly to the original interpretation of the Bass model, this study relies on the assumption of complete homogeneity of the densities of the times to adoption across the population. The interpretation of the G/SG differs from that given by Bemmaor (1994).

The data used are the monthly numbers of active, unique MSN users over an observation period of 67 months, starting in April 2007.[1] We also added two countries (Spain and Italy) from the same data source (comScore) in order to extend the scope of the analysis. Using three two-parameter models that allow for left-skew, symmetry and right-skew, respectively, as well as estimating the full three-parameter version of the G/SG, excluding the market size parameter, we show that all four models provide comparable fits to the data set, despite their apparently divergent implications. However, when used for

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[1] SGH made a data handling error in three countries out of four by summing the numbers of active and unique MSN users in months t and $t-1$ in order to obtain the number of active and unique MSN users in month t (the US is the exception). This error resulted in a doubling of the number of MSN users at the end of the observation period (October 2012).

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forecasting purposes, the shifted Gompertz leads to forecasts that are superior to those of the other models, in five countries out of six (France is the exception). Thus, from a predictive standpoint, the data are mostly consistent with right skew, which corresponds to a relatively thick right-hand tail. The following section provides a brief introduction to the three nested models and to the generalized G/SG, and to their characteristics in terms of the implied effect of network externalities. The third section reanalyzes the data set, while the fourth section forms the conclusion.

2. The models and their implied effects of network externalities

SGH tested the Bass model relative to the G/SG. Here, we estimate both the G/SG and three constrained two-parameter versions. The reason for this is that parameter identification issues can arise when the data are right censored, as is typically the case with diffusion data.

The G/SG is a three-parameter model with a cumulative distribution function that takes the following form:

$$F(t) = \frac{1 - e^{-bt}}{\left(1 + \beta e^{-bt}\right)^{\alpha}}, b, \alpha, \beta > 0, t > 0. \tag{1}$$

The advantage of this formulation is that it is relatively flexible: the probability density function (p.d.f.) can be skewed to the right, to the left or not at all, depending on the value of α. The model reduces to the Bass model when $\alpha = 1$. Letting $f(t)$ be the p.d.f, we can parametrize it as a function of (i) a coefficient of external influence, $f(0) = p$, which captures the likelihood of adopting at time $t = 0$, and (ii) a coefficient of the internal influence q, with $b = p + q$ and $\beta = q/p$ for the Bass model. Evaluated at $t = 0$, the p.d.f. of the G/SG is such as:

$$f(0) = p = \frac{b}{(1 + \beta)^{\alpha}}. \tag{2}$$

Letting $z(t)$ be the conditional likelihood of adopting at time t given that one has not adopted yet, with $z(t) = f(t)/(1 - F(t))$, it can be shown that $z(t)$ approaches b as t approaches ∞. It follows that:

$$b = p + q, \tag{3}$$

regardless of the value of α, and that

$$\beta = (1 + q/p)^{1/\alpha} - 1. \tag{4}$$

The G/SG can be parametrized as a function of p and q as follows[2]:

$$F(t) = \frac{1 - e^{-(p+q)t}}{\{1 + \left[(1 + q/p)^{1/\alpha} - 1\right] e^{-(p+q)t}\}^{\alpha}}, \quad t > 0, p, q, \alpha > 0. \tag{5}$$

[2] SGH (2015, p. 1162) parametrize the G/SG differently from us: in Eq. (1), they replace b with $p + q$ and β with q/p for all values of α. In this case, though, the parameters p and q cannot be interpreted as the coefficients of external and internal influence respectively, since $f(0)$ is a function of α (Eq. (2)). Hence, our estimates of p and q are not comparable with theirs (unless $\alpha = 1$). In our case, the interpretations of p and q are consistent regardless of the value of α.

Such a parameterization offers a common interpretation of the parameters of both the nested versions and the general version. Depending on the value of α, the shape of the conditional likelihood of adopting given that one has not adopted yet can vary substantially as a function of the cumulative proportion of adopters.

We study three special cases that include two parameters for estimation only and the generalized case (Eq. (5)). The cases are as follows:

- $0 < \alpha < 1$: Skew to the left with $0 < F(t^*) < 1$ (t^* : mode of $f(t)$).

The selected case is G/SG($\alpha = 1/2$), which exhibits a slight skew to the left ($0 < F(t^*) < 0.58$). The implied hazard rate is a convex function of the cumulative proportion of active MSN users: according to the model, the rate of change of the conditional likelihood of adopting (given that one has not adopted yet) *increases* with the cumulative proportion of adopters. The model captures an *increasingly* warming effect of network externalities: later adopters carry more weight in the diffusion curve than early adopters. On average, the rate of change over time is equal to q. Such a pattern in the effect of network externalities can apply when adoption induces switching costs, for example from one generation of the product to the next, which is gradually overcome by the attraction of the new version.

- $\alpha = 1$: Right-skewed distribution that approaches symmetry as p/q approaches zero

$(0 < F(t^*) < 0.5)$.

This is the Bass model, the shape of which has been studied by Mahajan, Muller, and Srivastava (1990). Here, the rate of change in the conditional likelihood of adopting (given that one has not adopted yet) as the cumulative proportion of adopters increases is constant; it is equal to q. This is the case where the hazard rate is a linear function of the cumulative proportion of adopters. Network externalities operate as a warming effect at a constant temperature. This can appear a relatively strong assumption.

– $\alpha = \infty$: Right skew: $0 < F(t^*) < e^{-1}$.

In this case, the G/SG reduces to the shifted Gompertz (SG) distribution.[3] The conditional likelihood of adopting a social service given that one has not adopted it yet is a concave function of the cumulative proportion of adopters: the marginal effect of the cumulative proportion of adopters on the conditional likelihood of adopting (given that one has not adopted yet) *decreases* as the cumulative proportion of adopters increases. The warming effect declines over time. On average, the rate of change is equal to q over the diffusion process. The effect of network externalities tapers off as the number of active MSN users builds up: early adopters have more impact on potential adopters than later adopters. This is consistent with the "decay factor" in collective attention that Wu and Huberman (2007) refer to. Recently, the SG distribution has been shown to be superior to the Bass model for describing the search frequencies

[3] When α gets close to ∞, the G/SG approaches a SG. There is an error in SGH (p. 1162) on the limit distribution. The "Bass model" is a shifted logistic curve.