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The ACMI Adoption Model
- predicting the diffusion of innovations

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Abstract

*The ACMI (*Adoption Curve Modelling Instrument*) Model takes two well-known System Dynamics Models and combines them with the sociological theory of Memetics to form an Innovation Diffusion Model that can be used to predict the uptake of innovations within specific target consumer markets.*

Keywords: ***Bass Model, SIR Model, Memetics, Innovation, Diffusion, Adoption, Forecasting.***

The ACMI Adoption Model

We have developed a model that helps to predict the diffusion of innovations. It combines the structured approach of System Dynamics with the sociological theory of Memetics for parametrization of the model. Memetics theorizes that behaviour patterns can be copied from one person to another. In this case, we will estimate the behaviour patterns of people buying, using, rejecting and discarding innovative products by matching target group characteristics with product characteristics. These estimated behaviour patterns drive the flows that in turn affect the stocks of people in the model. The structure of these stocks is based on two well-known System Dynamics Models.

This article describes the ACMI model. First, the two established SD models are described. Then, the ACMI model is introduced. Finally, the behaviour theory and the estimation of the model parameters is discussed.

The Bass and SIR models

The ACMI Model has two well-established models as a basis: the Bass Model (Bass, 1969) and the SIR Model (discussed in Sterman, 2000).
The Bass Model describes the uptake of innovations, while the SIR Model represents an epidemic outbreak.

The System Dynamics representation of the **Bass Model** has two stocks and three loops. It contains two ways for a person to become a customer: either through *innovation* or through *imitation*. Innovation is also called the 'external effect' – someone becomes a customer because he has seen advertising, or is (actively) looking for the product. The imitation effect is more passive: a person only becomes a customer after he has come into contact with someone who is already a customer.

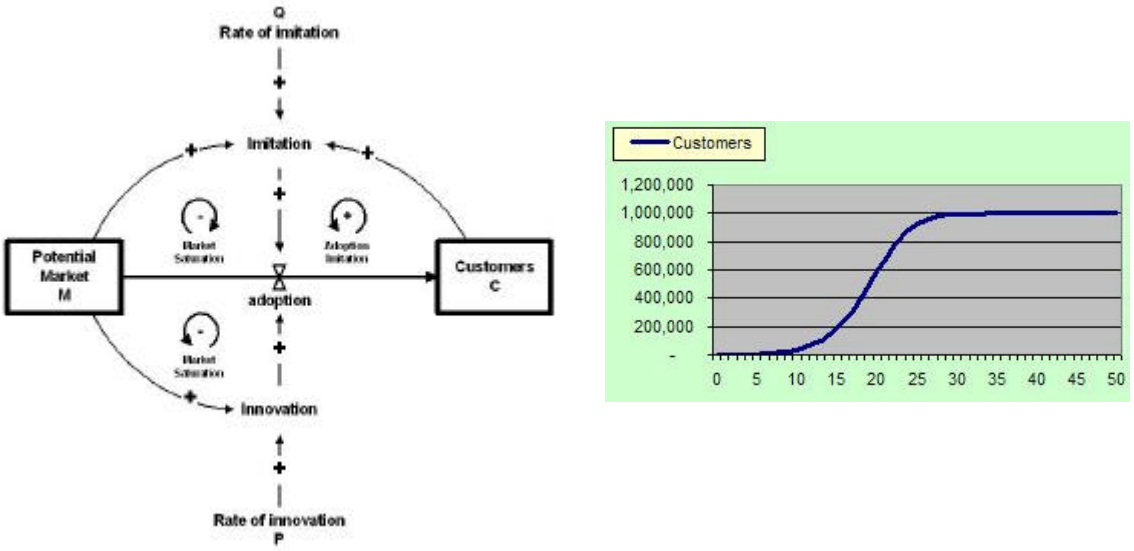

Figure 1 – Bass Model and its typical behaviour
(initial value of M = 1,000,000)

The imitation loop is reinforcing, and will make the innovation uptake (measured by the stock of customers) behave like the first half of an S-curve. After the inflection point, the balancing loops take over and the model will converge to an equilibrium in which eventually all people in the system have bought the product.

The **SIR Model** describes an epidemic and has three stocks: susceptible people (S), infectious people (I) and recovered people (R). It has three loops. During the outbreak of the epidemic, the reinforcing loop "contagion" is dominant. Depending on the duration of the illness, people recover and the epidemic declines again. Typically, not all individuals are struck by the illness.

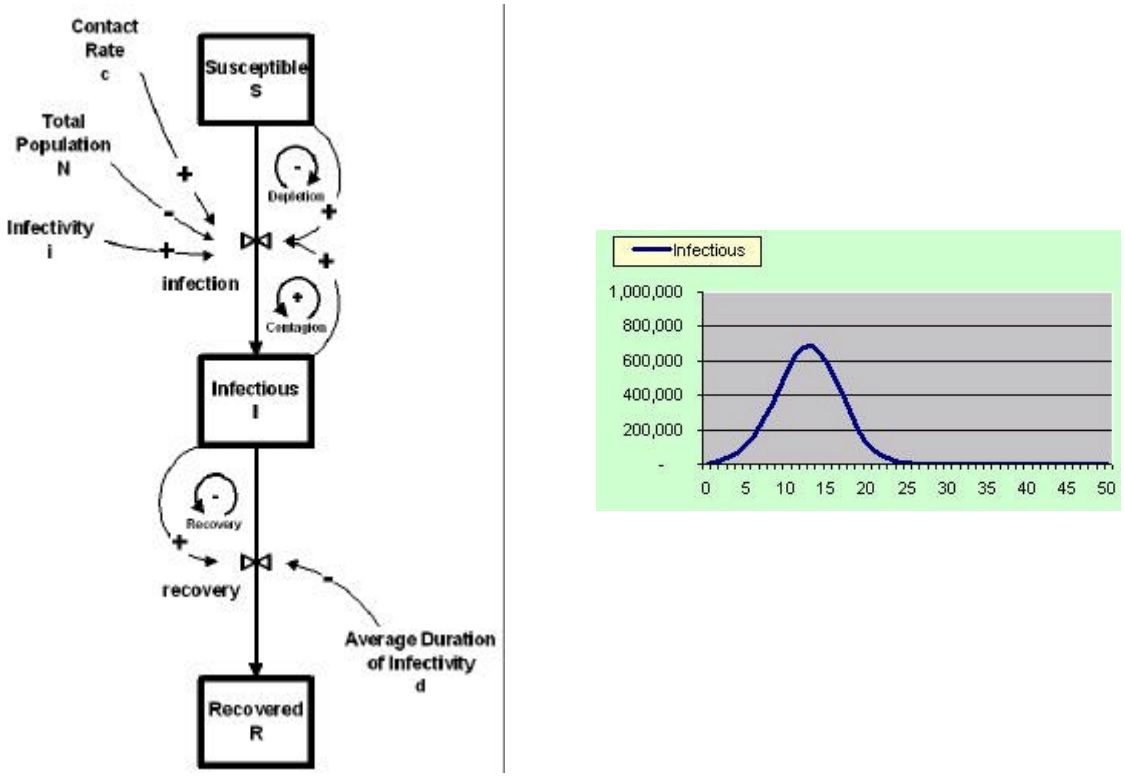

Figure 2 – SIR Model and its typical behaviour
(initial value of S = 1,000,000)

Structure of the ACMI Model

The ACMI Model combines the Bass and SIR Models. It has three stocks: a Potential Market (M), the customers (C) and a stock of non-customers – people who have either been a customer or have decided they do not want to own or use the product (N). The initial size of M should be set equal to the size of a pre-determined target group of customers. The initial values of C and N are zero.

There are three flows between the stocks. The first flow – Adoption (A) – represents people buying the product. This flow works similar to the flow in the Bass Model: people adopt the product by either innovating or imitating others. The second flow – Discarding (D) – represents the temporary aspect of being a customer: after a certain amount of time, a person moves from being a customer to the stock of ex-customers. This can happen if the product stops working, if it stops fulfilling the needs of the customer, when the service contract has ended, and so on.
The third flow is the Rejection flow (R). This flow represents people who actively decide not to buy the product. This happens when (among other reasons) the product is too expensive, when a substitute ('better' product) is available, or when the product simply does not fit the customers' needs.

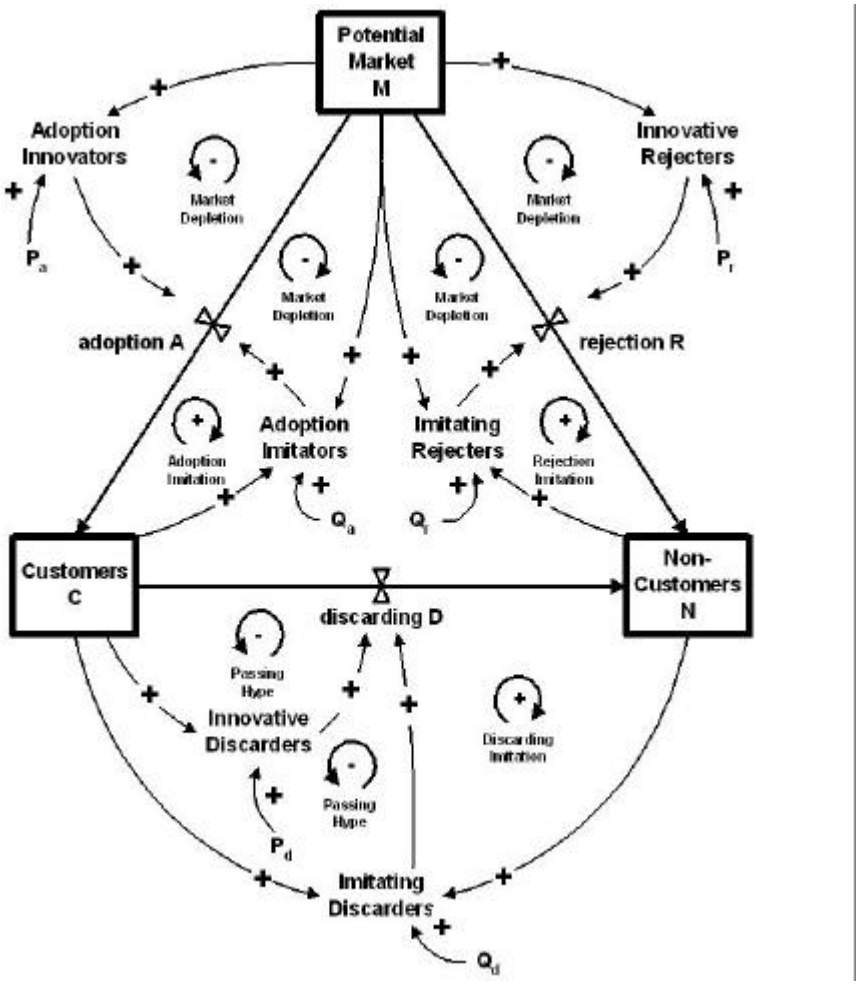

Figure 3 - The ACMI Model

Similar to the Bass Model, the main auxiliary variables are driven by parameters: P_a, P_d and P_r for innovation, and Q_a, Q_d and Q_r for imitation of Adoption, Discarding and Rejection respectively. We will estimate these parameters with the help of a sociological theory – memetics.

Memetics - estimating the parameters

In the ACMI model, the three different stocks and the relationships between them are predominantly drawn from the existing models (Bass and SIR). The one addition is that people can make a conscious choice not to become a customer (for example, by buying a competing product) and thus go straight from the Potential Market (M) stock to the Non-customer (N) stock.

It is necessary to understand what determines people's choices, in order to set the right parameters that drive the flows within the ACMI model. We have based the parameters determining the flows between the stocks, i.e. the reasons why

people choose to buy, use, reject or discard a product, on the sociological theory of *memetics* (e.g. Dawkins, 1976; Dennett, 1995). This is the theory that studies how ideas or units of behaviour spread within a population. Each idea or unit of behaviour is called a **meme** (pronounced to rhyme with *cream*). A meme, analogous to the gene, the unit of genetics, is an idea or information pattern which spreads through society. Memes can represent parts of ideas, languages, tunes, designs, skills, moral and esthetic values and anything else that is commonly learned and passed on to others as a unit. A key characteristic of a meme is that it is propagated by imitation or copying behaviour.

Memetics has the potential to provide an insight into which behaviours or ideas become successful within a society. The most likely behaviours to become widespread, according to a non-memetic perspective, will simply be those offering the most benefit to people. A memetic viewpoint, however, suggests that the behaviours which will be expressed the most will be those which are best suited to being copied. Sometimes this will be because a behaviour (such as the use of a new product) offers a relative advantage to the person (cf. Rogers, 2003) but sometimes it will only happen because that particular behaviour could be *easily copied*, as in the case of a here-today-gone-tomorrow hype. The theory of Memetics proposes that the most successful behaviours exhibit three attributes (cf. Dawkins, 1976; Blackmore, 1999):

1. **Fecundity**: the property that many copies of the idea or unit of behaviour are made. For example, the use of mass media advertising brings the idea of buying or using products to millions of people at a time.
2. **Fidelity**: the property that the copies are quite accurate. Once people have bought a new product having seen it on TV, they should be able to use it so that they receive the benefit of it and others can see them using it.
3. **Longevity**: the property that the copies are long-lived. If each person that buys the product keeps using it over a long period, then many others will come into contact with it.

Memetics is a good instrument to analyse the behavioural component of the use of products and services (Langley et al., 2004). In this particular case, the memes representing the knowledge of the product's existence and its use are important. With the use of memetics, we can estimate two important aspects of innovation diffusion. The first one is the speed with which a certain behaviour pattern (owning or using the product) will spread from one person (an existing customer) to another (a new customer). The second one is the time the meme will remain with a person, or in other words, the time a customer will remain loyal to the product.

For this to work, we will need to understand how people choose to adopt, retain or reject product-related behaviour patterns[1]. With the use of memetics, we can

[1] When a customer adopts a product, he simultaneously adopts the *behaviour* (a meme) that comes with owning or using that product.

estimate the six important parameters inherent to this process. These parameters are the following:

1. **P_a – Rate of Adoption innovation**. Some people, the "innovators" (Rogers, 2003), seek out new products and buy them simply because they are new. By matching the characteristics of these innovators with the aspects of the new behaviour that will appeal to them, we can calculate the relative rate of innovator adoption. This has much to do with "fecundity" and specifically the aspects of the new behaviour which stimulate innovators to try out the product.
2. **Q_a – Rate of Adoption imitation**. For people who are not innovators, the majority of the market, the process of imitation is crucial. Therefore, we need to address the speed with which the new behaviour pattern (owning or using the product) will spread from one person (an existing customer) to another (a new customer). What stimulates these people is a combination of "fecundity", "fidelity" and "longevity". Again we assess the match between the characteristics of the target group with the characteristics of the new behaviour.
3. **P_r – Rate of Rejection innovation**. Alternatively to the process described under 1), innovators can choose to reject an innovation either immediately when they first become aware of it, or very quickly thereafter. We calculate this by matching the innovators' characteristics with the product characteristics the new product does **not** offer.
4. **Q_r – Rate of Rejection imitation**. Analogously, non-innovators may be more likely to copy this rejection. Again this is determined by the looking at the aspects of the behaviour which are missing in the product but which are important to copying behaviour of the target group.
5. **P_d – Rate of Discarding innovation**. Once having used a product, some people spontaneously decide to cease using it. Perhaps they have become bored. Perhaps there is a competitor product which they have adopted. We calculate the likelihood that this will happen predominantly by looking at "longevity" and assessing how each target group is stimulated to remain loyal.
6. **Q_d – Rate of Discarding imitation**. Finally, people may discard a product they have used because others have discard it. Maybe the product has become "out of fashion". In this case the lack of loyalty to the product is the meme which is being copied.

The model can thus be extended to include the three memetics statistics fecundity, fidelity and longevity.

Behaviour of the ACMI Model

The three-stock nature of the ACMI Model means that its behaviour can be compared to that of the SIR Model. The number of customers, the stock variable in which we will generally be interested, can either take on an S-shaped curve or

(more generally) a rise-and-decline curve. One can reason that the diffusion of innovation behaves much like the spreading of an epidemic does. The elements that were copied from the Bass model – the innovation and imitation effects – can help to better understand what determines the precise height and shape of the curve.

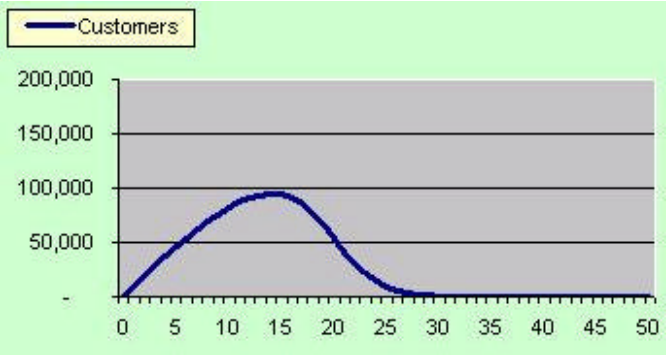

Figure 4 - Typical behaviour of the ACMI Model
(initial value of M = 200,000)

Conclusion

By combining Memetics in this way with existing SD models, a new approach to modelling the adoption of innovations has been developed. A new approach which offers, in principle, three major advantages over existing models.

The first of these is the fact that the ACMI model can estimate the uptake of an adoption based solely on the characteristics of the product and the characteristics and size of the target group. This data is already available *before* the product launch. Other models, including the Bass model, rely on early sales data for their prediction.

The second advantage of the ACMI model is that, unlike the Bass model, it predicts both the maximum adoption and the speed of adoption (the height and the shape of the curve).

The third major advantage of the ACMI model compared to other models is that the setting of parameters is based on a theory of how people adopt new behaviours (including the behaviours related to the use of products). In this way, more objectivity is brought into the process of assigning values to the parameters than is possible when experts themselves assign the values.

We are currently in the process of calibrating and validating the model to assess whether or not these potential major advantages carry over from theory to practice. The first results look promising.

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