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Firm level innovation diffusion of 3G mobile connections in international context

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ABSTRACT

Our objective is to explain the differences in the technology diffusion of 3G mobile phones at the firm level. Using a firm level diffusion model, we investigate: the effect of social globalization on within- and across-brand word-of-mouth communications; the impact of competitive fractionalization on the probability of adoption; and the effect of the population density on market potential. We use non-linear mixed modeling on pooled multi-country data from 123 firms in 40 countries to estimate a generalised firm level model. Our substantive findings are: social globalization has a positive impact on within-brand communications, and a negative impact on across-brand communications; competitive fractionalization has a negative impact on the probability of firm level adoption; and population density has a positive impact on the market potential. Finally, we demonstrate the model's validity using the model fit and predictive accuracy. Our findings will aid international managers in the evaluation of diverse international market forecasts for entries and regulators in their formulation of strategy and policy.

1. Introduction

It is well known that the diffusion of technological innovation occurs at different rates in different countries. For example, it took 12 years for 5% of Austrians to have a cellular telephone, but only 8 years for Australians to achieve the same penetration. When planning the development of national markets, insights into the causes of such differences in diffusion patterns are invaluable. In an attempt to provide extra insights, we develop a multi-country firm level model of the diffusion of *third generation* (3G) cellular technology. As a given technology develops, gradual improvements are always being made; occasionally though, a technological breakthrough occurs that allows either a sharp improvement in performance or a sharp decrease in cost, and this is regarded as a new generation of the technology. This is the case with 3G, whose benefits are significantly superior to the first digital phones, 2G. Here, we extend the firm level diffusion model suggested by Libai, Muller, and Peres (2009) and Savin and Terwiesch (2005). We develop this model in two directions. We modify the probability of adoption to include a marketing factor, in order to help identify the effects of competition and market share. We use pooled estimation of a multi-country, multi-firm model to better understand the drivers of diffusion both within and between firms. The logic here is that the multinational dimensionality of the data should allow us to estimate any differences in the firm level diffusion process with greater clarity than is possible with an individual country study. This benefit is in addition to the insights we expect to gain into the reasons for differences in the diffusion process between firms and between countries.

We address two aspects of 3G diffusion. Firstly, we look at the drivers of within- and across-brand word-of-mouth (WOM) communications, the effect of a marketing factor on the probability of adoption, and the effects of demographic variables on market potential. More specifically,

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we investigate: the impact of social globalization on *information transfer* and the *social learning* components of WOM communications; the impact of a marketing factor defined by competitive fractionalization on the probability of adoption; and the impact of population density on market potential. Secondly, we evaluate the predictive performance of the firm level multi-country model. We use an extensive data set which describes the adoption of 3G cellular telephones for 123 firms from 40 countries across all economic and geographic regions. The quarterly data span the period from the launch of the 3G phones in Q1, 2000, to Q1, 2009.

We make a number of substantive contributions which will aid managers and regulators in the formulation of both strategy and policy. We show the positive impact of social globalization in within-brand WOM communications, the negative impact of competitive effects on firm level diffusion, and the positive impact of the population density on market potential. Our methodological contribution, estimating a pooled multinational firm level model using a non-linear mixed model via the widely-available SAS program, will facilitate the proliferation of cross-country diffusion research. Furthermore, we also demonstrate the predictive validity of the multi-country pooled model.

In the following five sections, we present a literature review, a brief description of cellular technology, and our data, model and findings in relation to our research questions. We then consider model validity, and conclude by discussing the implications and limitations of the work.

2. Literature review and the development of research questions

We review the literature regarding the effects of within- and across-brand communications and their determinants, the effects of marketing factors on firm level innovation diffusion, and the impact of population density on market potential. We then conclude by formalizing our research questions and hypotheses.

2.1. Within- and across-firm (or brand) communications

In the category (i.e. country) level diffusion model literature, individuals are influenced by a desire to innovate and by a need to imitate others in the population. This latter process is also known as the contagion or the Word-of-Mouth (WOM) effect. In the case of category level diffusion, the WOM effect becomes stronger as more customers adopt, thus speeding up the diffusion of the innovation. The WOM process may simply be a mechanism of *information transfer* from a previous adopter to a new adopter (Katz & Lazarsfeld, 1955); *or* it can be due to *normative pressures* such as the adoption of an innovation with the approval of one's peers (e.g., Coleman, Katz, & Menzel, 1966; Davis, Bagozzi, & Warshaw, 1989); *or* it can be due to a *performance network effect* when the benefits of use and adoption increase with the number of prior adoptions (see Van den Bulte & Lilien, 2001, for a detailed discussion).

Mahajan, Sharma, and Buzzell (1993) introduced a firm (or brand) level diffusion model while modeling the growth of instant photography, marketed by Kodak and Polaroid, during the period from 1976 to 1995. In their model, the authors assumed that each firm (or brand) has its own incremental market potential, an assumption similar to that made in the case of the multi-generation model proposed by Norton and Bass (1987). According to them, new entrants bring product variety, which attracts new consumer segments, and prices are lowered due to the increased competition; this extra competition allows consumers with lower reference prices to enter the potential market. A number of other researchers (e.g. Peterson & Mahajan, 1978; Shankar, Carpenter, & Krishnamurthi, 1998) have also assumed a unique market potential for each brand. According to their model, existing adopters of a particular brand (either Kodak or Polaroid) generate WOM communications by interacting with the brand's potential consumers, as well as potential consumers of the other brands. To summarize, the imitator category of consumers comes from all potential consumers of all brands, but is only influenced by its own brand's previous adopters. While developing a brand level diffusion model for the cellular phone market, Krishnan, Bass, and Kumar (2000) noted that the imitation category of a particular brand's sales will be affected by its own previous adopters as well as previous adopters of all other brands in the market. Instead of modeling a different WOM effect from each brand's previous adopters and previous adopters of other brands, they assumed that a collective force of all previous adopters will act on each brand's future adoption. Their model is parsimonious but does not distinguish between the WOM from a brand's own previous adopters and that from the previous adopters of other brands. Savin and Terwiesch (2005) separated these two types of WOM (within-brand and across-brand) to model firm (or brand) level diffusion. Libai et al. (2009) were the first to produce empirical estimates of the within- and across-brand WOM effects suggested by Savin and Terwiesch (2005). Libai et al. (2009) propose a more general model that encompasses several other models under certain restrictions (e.g., Givon, Mahajan, & Muller, 1995; Kim, Bridges, & Srivastava, 1999; Krishnan et al., 2000; Parker & Gatignon, 1994).

WOM is an informal channel of communication that disseminates market information, and is particularly complex and difficult to evaluate. In the context of innovation diffusion, WOM has been taken into account in a cross-national study by Takada and Jain (1991). Takada and Jain (1991) compared homogeneous communications in Pacific Rim countries with the more heterogeneous culture in the USA. They found that WOM communications were facilitated better within homogeneous populations than in heterogeneous populations. Japanese consumers (from an individualistic, high context culture) make more use of WOM in their purchase decisions than do American consumers (see Bruce, Gilly, & Graham, 1998). Chung and Darke (2006) also noted cultural differences in WOM communications. According to them, collectivist consumers did not distinguish between self-relevant and utilitarian products when communicating through WOM, but individualist consumers provide WOM communications for self-relevant products only. In the context of the cross-national diffusion of innovations, Van den Bulte and