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Abstract

Purpose – *This paper aims to investigate, inside the private sector of transport, a model for the diffusion of knowledge-sharing technologies with non-uniform internal influence that has been developed by Easingwood* et al. *(1983).*

Design/methodology/approach – *The authors performed an empirical evaluation of the performances of the model by Easingwood* et al. *(1983) by analyzing data gathered from almost 230 taxi drivers joining two of the biggest taxi brokers operating in the Southern Italian city of Naples.*

Findings – *Such an analysis reveals that the model by Easingwood* et al. *(1983) provides an excellent agreement with the empirical data and allows to obtain interesting predictions on the future evolution of the sector performances in terms of increasing use of knowledge-sharing technologies within the taxi drivers' community of practice (CoP).*

Research limitations/implications – *In particular, the authors show that a unique solution always exists, which is defined on the whole (positive) set of times and, in the long run, tends to a steady-state equilibrium. A first limit of the present research is certainly the use of a sample restricted to the taxi companies from only one city: future investigations should consider a larger sample by interviewing taxi companies from multiple regions as well. Another limit is that the model performed does not take into account all the factors influencing the diffusion of knowledge-sharing technologies within the CoP. Finally, the research design is not considering the impact of the diffusion of knowledge-sharing technologies on the customer relationship management.*

Originality/value – *The research shows the application of a valid model both for evaluating the diffusion of technologies for sharing knowledge within a CoP and for estimating its development trend. It represents the first original study in Italy that empirically investigates the diffusion of technological innovations for the knowledge management in an industry typically dominated by tacit codes of knowledge-sharing: the taxi companies.*

Keywords *Knowledge-sharing, Diffusion of innovation, Community of practice, Private transport sector, Taxi drivers, Technology forecasting*

Paper type *Research paper*

Introduction

In the management field, a considerable research effort has been spent in developing analytical models that try to explain the process of diffusion of knowledge-sharing technologies within a community of potential adopters. The authors evaluate the literature on the diffusion models in marketing management focused mainly on communication channels by which the information about an innovation is transmitted. One of these models, which is still nowadays very popular among researchers and practitioners, is that developed by Bass (1969). According to this model, which combines and generalizes previous concepts and findings (Fourt and Woodlock, 1960; Mansfield, 1961), the potential adopters of a technology are influenced by two kinds of communications. One group of adopters, referred to as "innovators", are driven by mass-media communications, that is, by external influence. Another group of adopters, referred to as "imitators", are driven by word-of-mouth communication, that is, by internal influence (Norton and Bass, 1987;

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Dodson and Muller, 1978; Hongxing and Pengfei, 2012; Horsky, 1990; Horsky and Simon, 1983; Jain and Rao, 1990; Kalish, 1983, 1985; Kalish and Lilien, 1986; Libai *et al.*, 2009; Mahajan, 1993; Parker and Gatignon, 1994; Robinson and Lakhani, 1975; Peres *et al.*, 2010).

Moreover, Easingwood *et al.* (1983) have proposed a generalization of the Bass model to the case of a non-uniform (time varying) internal influence. Such an approach appears to be very interesting, because of the following reasons: first of all, it allows modeling of the non-constant nature of the word-of-mouth effect; second, it is a parsimonious extension, as only one additional parameter is introduced and the structure of the original Bass model is preserved.

The authors here present a theoretical and experimental analysis of the model by Easingwood *et al.* (1983) by performing an empirical evaluation of the uses and diffusion of knowledge-sharing technologies and by applying it to the Southern Italian sector of private transport (taxi companies). In particular, the authors show that a unique solution always exists, which is defined on the whole (positive) set of times and, in the long run, tends to a steady-state equilibrium.

Theoretical background

A large amount of literature has investigated the knowledge-sharing processes and technologies from two distinct theoretical viewpoints. Starting with Roger's (1983) studies regarding the early and late users of technological innovations, as well as with Szulanski's (1996) analysis of best practices transfers within firms, a number of researchers have examined in detail the elements that cause difficulties in knowledge transfers, basing their studies on the communications theory (Shannon and Weaver, 1949). As stated by Szulanski (1996), this theory argues that knowledge transfer and sharing may be conceptualized as the transmission of a message from a source to a recipient in a particular setting. Moreover, the message or the situation could have certain features, limiting the quantity of transferrable knowledge, which may result in a stickier transfer. As pointed out by Szulanski (2000), in recent times, this field has increasingly attracted the attention of organizational learning theories, as not only a set of communications is deemed relevant for the success of knowledge transfers but also a constant process of learning interactions.

Seemingly, management scholars analyzed the different variables that may influence either technology transfer and innovation research or knowledge-sharing practices (Nicotra *et al.*, 2014; Del Giudice *et al.*, 2011, 2012; Chase, 1997; Della Peruta and Del Giudice, 2013). Particularly, they focused on a series of specific factors such as the tacitness and the embeddedness (Zander, 1991; Szulanski, 1996, Dinur *et al.*, 1998; Dixon, 2000; Garcia-Perez and Ayres, 2010), the soundness of relationship ties that link the parties to one another (Hansen, 1999), the recipient's ability to learn and understand (Yeung *et al.*, 1999; Bedford, 2012) and the sharing activities carried out (Dinur *et al.*, 1998; Davenport and Prusak, 1998).

Management and information technology scholars noted that the attempt to create a management culture of shared knowledge certainly takes its impetus from the growth of computational power of storage and communication on the part of information and communications technology, from the first limited power of computers to almost infinite potential of the networks and the "clouds" server (cloud computing) (Del Giudice and Straub, 2011). The current evolution of the Internet to the Web with the development of social networks of communication between people who generate content and messages continuously interacting with each other is radically transforming the traditional communication flows and, consequently, the way knowledge is shared among individuals (Del Giudice *et al.*, 2014; Della Peruta, 2014).

The availability of Internet tools able to overcome the physical encounter between people but still able to support the sharing of knowledge has enabled the consolidation, at a more general level and across many sectors, of the CoPs. In the managerial literature, the concept of community of practice (CoP) is often compared to the knowledge-sharing process (Del Giudice *et al.*, 2013; Del Giudice and Maggioni, 2014); it has become quite popular after Lave and Wenger's analysis (1991) and the organizational studies by Orr, 1990 and Brown and Duguid (1991, 1998, 2001a). In addition, the concept influenced the knowledge management literature both directly and indirectly (Lesser and Everest, 2001; Scarborough, 2009). Scholars defined CoPs in several ways, although there is a general agreement about their nature and purpose. As pointed out by Wenger and Snyder (2000), CoPs are similar to informal groups that have in common shared expertise and passion for a joint enterprise. They are seen as based on relationships, they attract members because of the sense of identity they provide, and their shared memory and knowledge are openly diffused within and among communities and, sometimes, cross-organizational boundaries (Brown and Duguid, 2001a), although in that case, they remain within the limits of a particular professional occupational grouping (Van Maanen and Barley, 1982). Lave and Wenger (1991) describe them as a "set of relations among persons, activity and the world, over time and in relation with other tangential and overlapping communities of practice". They tend to be self-selecting, self-organizing, self-reinforcing and self-renewing (Wenger and Snyder, 2000; Lesser and Everest, 2001).

Following those premises, the authors in the present study look at taxi drivers as a CoP sharing knowledge, sometimes when they occasionally meet in the parking areas, other times, more recently, through Internet-based technologies (e.g. blogs, forum, Web pages, etc.). Their original research goal has been to introduce and evaluate a mathematical model that is able to understand and predict the diffusion of knowledge-sharing technologies inside a CoP that, on the contrary, has always been characterized by its tacit knowledge-sharing codes. That is because the components and the organizational implications of knowledge management show that the purpose of technology for knowledge-sharing should be not only to manage knowledge itself but also especially to facilitate the implementation of innovative processes underlying them. It is certainly true that, as noted by Trudel (1996), taxi driving is supported by a culture of individualism and a short-term, anti-cohesive mentality; similarly, Sellers *et al.* (1997) referred to taxi drivers as "maverick lone cowboys", focusing on their isolation and alienation. In fact, they directly compete with one another for their income, and, as stated by Davis (1965), their isolation is increased by the fleeting nature of their relationship with the customers. However, nowadays, taxi communities are becoming more similar to real CoPs. It is now clear that they are bound by a community culture, based on shared experience and common norms and rituals. There is no formal induction process, but a complex social network is reinforced on a daily basis through gatherings and contact points. Socialization among taxi drivers who work for the same company can be particularly engaging, revealing strong connections and the existence of unspoken rules of trade. Drivers may place their cab in a queue without actually parking it in the line; if a newbie does not understand how things work, somebody with more experience, who will introduce him to the unwritten rule, will approach him. Especially when taxi drivers are at the rank, they will tell stories and exchange experience, and all this contributes to identity construction and informal learning. This way, the organization's knowledge system is constituted, negotiated and enacted through effective CoPs (Orr, 1990; Brown and Duguid, 1991; Wenger, 1998). Nevertheless, it is evident that, differently from other organizations and occupations, meetings among taxi drivers are not predictable, as socialization may be interrupted at any time by the arrival of a customer.

The research design

Taxi driver companies are organized as cooperatives of several individual entrepreneurs (i.e. "taxi brokers"): each taxi driver usually pays a monthly fee to the taxi broker to use common services and/or technologies (e.g. inter-communication technologies, use of parking areas, use of the cooperative brand equity and awareness, use of the brokers' Web areas, etc.). Prior to the diffusion of blogs and social networks, taxi brokers were using a knowledge-sharing system exclusively based on the Central Radio. The drivers were maintaining a considerable amount of information and knowledge about the rides (e.g. details about destinations, formation of traffic during on-peak hours, rates to be charged, customers' experiences, etc.), and they were sharing them indirectly with the whole fleet through the Central Radio. This system has allowed taxi drivers to observe some patterns of recurring features in time (similar requests and destinations, homogeneous preferences, etc.), thus making them learn and distinguish the most interesting and profitable rides (e.g. customers visiting the city), from the low profile ones (e.g. random rides or targeted workplace or nearby places). Anyway, the great quantity of information to be managed, as a consequence, has encouraged the taxi brokers to develop and adopt better tools for knowledge-sharing, to allow the taxi drivers to identify their best job opportunities. For this reason, since 2013, taxi brokers have progressively adopted either technologies for knowledge-sharing based on social networks and blogs or apps that help the passengers locate the taxi drivers and use the broker's services. This has resulted in a strong network of shared experiences and in an information flow that has allowed the taxi drivers to perform their daily work more efficiently.

In the present study, data from almost 230 taxi drivers working for two of the biggest taxi brokers (namely, "2222" and "8888") operating in the Southern Italian city of Naples have been collected through direct oral interviews with the taxi drivers. Interviews based on just 12 items were collected by the authors from May 2014 to October 2014 during taxi rides. Data were gathered on a tablet during the taxi rides for later analysis. Every interview was conducted at total ease by the authors, who behaved at first as normal passengers and later declared their intention of carrying out an interview for research purposes. Furthermore, a number of in-depth interviews preceded the phase of the direct interviews with two members of the management team (a dispatcher and a remote operator) of each taxi broker, to understand the knowledge-sharing operational practices within the company and to elaborate the questionnaire's items. The authors held the interviews on several days and repeatedly addressed the same interviewees for data verification and elaboration on statements. A substantial amount of secondary source data on the Naples taxi trade and taxi industry in general was also obtained from institutional bodies (e.g. the Chamber of Commerce), relatives of taxi drivers, Internet sites on the taxi trade worldwide and any taxi driver who was encountered while engaging their services.

The authors measured the adoption rate of knowledge-sharing technologies by cumulating results stemming from the items emerged and validated during the phase of the in-depth interviews as follows:

- Average yearly number of Web accesses to blogs and Web platforms used by the interviewees (2011-2013 data were gathered from the interviews; they were later checked and validated by the authors by using the "Google trends" app).
- Average yearly number of accesses to groups of taxi drivers within the main social networks (2011-2013 data were gathered from the interviews).
- Average yearly number of "Whatsapp" accesses to groups of taxi drivers (2011-2013 data were declared by the interviewees).
- Average yearly number of uses of specific apps for taxi drivers (the most used app, "it Taxi", created by the Italian Union of Radio Taxi, started in 2012, and it allows to request, or to book, a taxi in the fastest way by identifying the customer's position and sending the request directly to the Central Radio. The app allows to release a feedback on the most or least popular taxi drivers which can be shared with the Central Radio and, subsequently, with the whole fleet (data were gathered from the interviews).
- Average yearly number of uses of technologies specifically developed for the taxi drivers' community (2011-2013 data were gathered from the interviews and included

“The introduction of knowledge sharing technologies, like the social network or the Internet based ones, replaced the previous network with regulated and formalized means of interaction that do not integrate existing deeper structures.”

the use of cloud based apps, integrated VoIP with Caller-ID, GPS with real time vehicle position and status updates, software with automatic route calculation and fare estimation, apps with support for passengers with predefined trips, software with auto-completion of addresses, apps that examine job queues and free slots for vehicles, apps with support for multiple auto-assignment schemes, e.g. zone-queues, FIFO, nearest or best vehicle, software with passenger text-back on car dispatched and car waiting as well as with automatic alerts for late vehicles, etc.).

The sum of the above-mentioned numbers gave back to the authors the average yearly *cumulative number of uses of knowledge-sharing technologies by the taxi drivers*.

Data gathered about the adoption and diffusion of knowledge-sharing technologies inside the investigated community allowed the authors to investigate the following:

- How taxi drivers share tacit knowledge by exchanging impressions, “professional secrets” and advice about which tools and innovations may improve their daily work. Results easily revealed that, although from 2011 to the beginning of 2013, knowledge was scarcely exchanged between taxi drivers, *au contraire* starting from 2013, thanks to the rapid diffusion of blogs, social networks and communication apps on smartphones, available tools and opportunities to exchange knowledge increased dramatically.
- How much taxi companies support the diffusion of technological innovations aiming at providing progressively better knowledge-sharing tools available to the taxi drivers’ community.
- Which evolution can be expected for the private transport sector examined, given the importance of those knowledge-sharing practices among taxi drivers. The authors’ investigation reveals that the model by Easingwood *et al.* (1983) provides an excellent agreement with the real data and allows for obtaining interesting predictions on the future evolution of the diffusion of innovation inside the sector.

The empirical analysis has been organized as follows:

- first, the basic facts about the model by Easingwood *et al.* (1983) are recalled;
- then, a theoretical investigation of the model is carried out;
- third, the calibration of the model parameters to sector data is performed; and
- finally, the results of the numerical simulations are discussed.

The empirical model

Let $N(t)$ denote the cumulative number of persons who at time t have already adopted a certain innovative technology (in the present study, $N(t)$ denotes the number of cumulative uses of knowledge-sharing technologies, as formerly expressed). According to the popular model proposed by Bass (1969), $N(t)$ satisfies the following ordinary differential equation:

$$N'(t) = \left(p + q\frac{N(t)}{M}\right)(M - N(t)) \tag{1}$$

where $p > 0$ and $q \geq 0$ are referred to as coefficients of innovation and imitation, respectively, and $M > 0$ denotes the total number of potential adopters (consequently, in the present research, M denotes the number of potential uses of knowledge-sharing technologies within the considered community).

Easingwood *et al.* (1983) have generalized the above model so as to incorporate the time-varying nature of the word-of-mouth effect, e.g. through the word-of-mouth. In particular, they consider a time-varying imitation coefficient:

$$q(t) = r\left(\frac{N(t)}{M}\right)^{\alpha}, \tag{2}$$

where α is constant and $r \geq 0$. Substitution of equation (2) in equation (1) yields the model by Easingwood *et al.* (1983):

$$N'(t) = \left(p + r\left(\frac{N(t)}{M}\right)^{\delta}\right)(M - N(t)), \tag{3}$$

where $\delta = \alpha + 1$. Easingwood *et al.* (1983) assume that $\delta \geq 0$, so that the right hand side of equation (3) is meaningful also if $N(t) = 0$. In fact, equation (3) is usually equipped with the initial condition:

$$N(t_0) = 0, \tag{4}$$

which reflects the fact that the innovation technology is launched on the market at a certain time t_0.

Note that if $\delta = 1$, the model equation (3) recovers the original Bass model equation (1).

The Cauchy ordinary differential problem equations (3) and (4) does not have an exact closed-form solution, and thus, some numerical approximation is required.

Theoretical analysis

From the theoretical standpoint, we can prove the following proposition, which ensures that the model by Easingwood *et al.* (1983) has a unique solution.

Proposition

Assume that $p > 0$, $\tilde{q} \geq 0$, $\delta \geq 0$. Then, problem equations (3) and (4) have a unique solutio n $N(t)$ defined for all $t \in [0, +\infty)$. Moreover, $N(t)$ *is* non-negative, monotone non-decreasing and such that $\lim_{t \to +\infty} N(t) = M$.

Proof

First of all, we note that any solution $N(t)$ of equations (3) and (4) is non-negative, non-decreasing and bounded from above by M. In fact, assume that $N(t) > M$ for some t. Then, as $N(0) = 0$, there is some $\bar{t}$ such $N(\bar{t}) = M$ and $N(t) < M$ for all $t \in [0, \bar{t})$. However, the right hand side of equation (3) is locally Lipschitz at $N = M$, so from the standard theory of ordinary differential equations (Hartman (2002)), it follows that a unique constant solution $N(t) = M$ exists for all $t \in [\bar{t}, +\infty)$, which contradict the fact that $N(t) > M$ for some t. Moreover, any solution of equations (3) and (4) must be non-negative and non-decreasing, which follows immediately from equation (4) and from the fact that the right hand side of equation (3) is non-negative (as $N(t) \leq M$). Furthermore, from equation (4), we have $N(0) > 0$, implying that any solution $N(t)$ is strictly positive for $t > 0$.

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"The current study introduced and confirmed that social web tools and technological opportunities are likely to be among the latest enablers of tacit knowledge sharing in the private transport sector."

Now, let us prove that at least one solution exists for all times $t \in [0, +\infty)$. First of all, as the function at the right hand side of equation (4) is continuous, and thus, the Peano theorem (Hartman (2002)) implies that one solution $N(t)$ exists at least for $t \in [0,t')$, where t' is some positive time. However, as it should be $N(t') > 0$, the right hand side of equation (3) is locally Lipschitz for $t = t'$, and thus, the solution $N(t)$ can be prolonged on a bigger (maximal) interval, say $[0,t'')$, where $t'' > t'$ (Hartman (2002)). Nevertheless, $N(t)$ is bounded for all $t > 0$, and so is also $N(t)$ for all $t \geq t'$ [which immediately follows from the right hand side of equation (3)], and thus, we can apply the standard theory of ordinary differential equations and conclude that $t'' = +\infty$.

To establish uniqueness, it is enough to prove that the solution is unique on some (finite) time interval $[0,\tilde{t}]$. In fact, as we have already shown, for all $t > \tilde{t}$, any solution $N(t)$ must be strictly positive, which implies that the right hand side of equation (3) is locally Lipschitz, and according to the standard theory of ordinary differential equations, we can conclude that the solution is unique also on $[\tilde{t}, +\infty)$. Then, let us consider the change of variables $Y(t) = -\ln(M - N(t))$, which allows us to rewrite problem equations (3) and (4) as follows:

$$Y(t) = p + r\left(\frac{M - e^{-Y(t)}}{M}\right)^{\delta}, \qquad (5)$$

$$Y(0) = -\ln M. \qquad (6)$$

Any solution $Y(t)$ of equations (5) and (6) is, therefore, implicitly defined by:

$$\int_{-\ln M}^{Y(t)} g(u)du = t, \qquad (7)$$

where:

$$g(u) = \frac{1}{p + r\left(\frac{M - e^{u}}{M}\right)^{\delta}}. \qquad (8)$$

Now, as the function $g(u)$ is continuous at $u = -\ln(M)$, the implicit function theorem allows us to conclude that there is a convenient time interval $[0,\tilde{t}]$ in which a unique function $Y(t)$ satisfying equation (7) exists. As already noticed, this allows us to conclude that problem equations (3) and (4) has a unique solution $N(t)$ defined for all $t \in [0, +\infty)$.

Finally, the asymptotic behavior $\lim_{t \to +\infty} N(t) = M$ easily follows from the fact that $N(t)$ is limited and monotonically non-decreasing and because the right hand side of equation (3) is zero only for $N(t) = M$.

Empirical analysis

In this section, we use the model equations (3) and (4) to evaluate and forecast the time evolution of knowledge-sharing technologies inside the community of taxi drivers. As evidenced from the gathered data, knowledge-sharing practices among the drivers dramatically increased, starting from 2013, thanks to the emerging of software-based technologies: that evidence stimulated the taxi brokers to adopt progressively new innovative technologies to simplify the taxi drivers' daily work and offer better services to their passengers. Therefore, it appeared interesting to make some predictions on the time evolution of such a sector, which is done using the model by Easingwood *et al.* (1983).

To this aim, first, let us calibrate the parameters of equation (3) by fitting to sector data. In this regard, note that we have to estimate not only the coefficients p, r, δ but also the coefficient M. However, the number of taxi drivers who could be interested in using a knowledge-sharing technology (and, mainly, how much they will use it) is somehow difficult to obtain using direct statistics or other usual data-gathering techniques. Therefore, we decide to treat M as an unknown model coefficient, just like p, r, δ, and estimate all these four parameters by calibration to empirical data. Let $N_{emp}(t)$ denote the cumulative number of uses of knowledge-sharing technologies from the beginning of year 2011 to the beginning of year $t, t = 2011, 2012, , 2014$. Clearly, we have $N_{emp}(2011) = 0$, so that the null initial condition equation (4) is prescribed for $t_0 = 2011$.

Let us consider the distance between the real market data $N_{emp}(t)$ and the theoretical adoptions $N(t)$ predicted by the model by Easingwood *et al.* (1983), measured according to the discrete L-square norm:

$$f_{obj}(p, r, \delta, M) = \sqrt{\frac{1}{3}\sum_{j=2011}^{2014}(N(j) - N_{emp}(j))^2}. \quad (9)$$

Note that, as explicitly indicated, f_{obj} depends on the parameters p, r, δ, M, simply because $N(t)$ does. Following a common approach, suitable estimations of the parameters p, r, δ, M, hereafter denoted $\hat{p}$, $\hat{r}$, $\hat{\delta}$, $\hat{M}$, are computed by minimizing the function equation (9), which, therefore, is referred to as objective function:

$$(\hat{p}, \hat{r}, \hat{\delta}, \hat{M}) = \arg\min_{p, r, \delta, M} f_{obj}(p, r, \delta, M). \quad (10)$$

Note that the function $N(t)$, i.e. the solution of problem equations (3) and (4), cannot be computed using an exact analytical formula. Therefore, in equation (9), in place of $N(t)$, we use a very accurate approximation of it which we obtain by employing a fourth-order Runge–Kutta time discretization scheme with 600 time steps over the time interval (2011, 2014) (Quarteroni *et al.* (2000)). Finally, the optimization problem equation (10) is solved by means of the popular Brent method, which is iteratively employed along alternating coordinate directions (as it applies to functions of a single variable). For a comprehensive description of such an algorithm, the interested reader is reminded to Brent (1973). Here, we only make notice that the Brent method does not require knowledge of the gradient of the function to be minimized and, thus, is particularly suitable to solve problem equation (10), as the derivatives of the function $f_{obj}(p,r,\delta,M)$ are not available [as the function $N(t)$ needed to compute equation (9) is approximated numerically].

Numerical results

The values of the model parameters obtained using the calibration procedure described in the previous section are shown in Table I. Note that in this table, we also report the optimum of the objective function, namely, $\hat{f}_{obj} = f_{obj}(\hat{p},\hat{r},\hat{\delta},\hat{M})$.

First, let us observe that the estimated parameter $\hat{p}$ looks relatively small (it is of order 10^{-6}). However, this fact does not imply that the contribution of the innovation term is negligible because, according to equation (3), $\hat{p}$ must be multiplied by $(M - N(t))$, which is of the order 10^5. Furthermore, the estimated value $\hat{\delta}$ is significantly smaller one; this implying that the word-of-mouth effect [measured by the imitation coefficient q; see equation (2)] is far from being constant in time. Nevertheless, looking at Table I, the most relevant facts are as follows:

Table I Model parameters, estimated values

$\hat{p}$	$\hat{r}$	$\hat{\delta}$	$\hat{M}$	$\hat{f}_{obj}$
4.797×10^{-6}	1.921×10^{-1}	6.203×10^{-1}	1.096×10^{5}	7.108×10^{2}

1. The model by Easingwood *et al.* (1983) provides a very satisfactory agreement with the real data. In fact, $\hat{f}_{obj}$ is equal to 7.108×10^2 and, thus, is very small if compared to $N(t)$, which is often of order 10^4 (Figure 1). Such an excellent performance of the model is also confirmed by the behavior of $N(t)$ and $N_{emp}(t)$, which are plotted in Figure 1: as we can see, the number of uses predicted by the model fits the empirical data extremely well.
2. The model by Easingwood *et al.* (1983) predicts that the cumulative number of uses of knowledge-sharing technologies in the considered community will be of order 10^5 ($\hat{M} = 1.096 \times 10^5$). This is a relatively small value if we think that nowadays, the average yearly number of cumulative uses for the considered knowledge-sharing technologies is already equal to (approximately) 4.5×10^4 and that in the considered community, the majority of the taxi drivers is still using traditional knowledge-sharing practices (i.e. exchanging knowledge when meeting in the parking places).

Figure 2 shows the future time evolution of $N(t)$ obtained using the model by Easingwood *et al.* (1983) with the parameters reported in Table I. We can observe that as t tends to infinity the cumulative number of adopters tends to the limit $\hat{M}$, which confirms the theory developed in Section 3. Moreover, for values of t larger than 2040, $N(t)$ is already extremely close to the asymptotic value $\hat{M}$.

Conclusions

Turning to the drivers, prior to the introduction of multiple knowledge-sharing tools, information and knowledge transfer were deeply linked to ongoing radio interaction, a function that served to create a "virtual" network whereby all members directly participated in and "heard" the organization doing its work. Similarly, informal gatherings at taxi ranks and coffee stops during slack times served as a key opportunity for community engagement and socialization. In these ways, members of the organization constituted, negotiated and enacted the organization's knowledge system essentially through tacit and not formalized codes of knowledge-sharing, typical of the CoPs. However, the introduction

Figure 1 Uses of knowledge-sharing technologies, empirical and theoretical

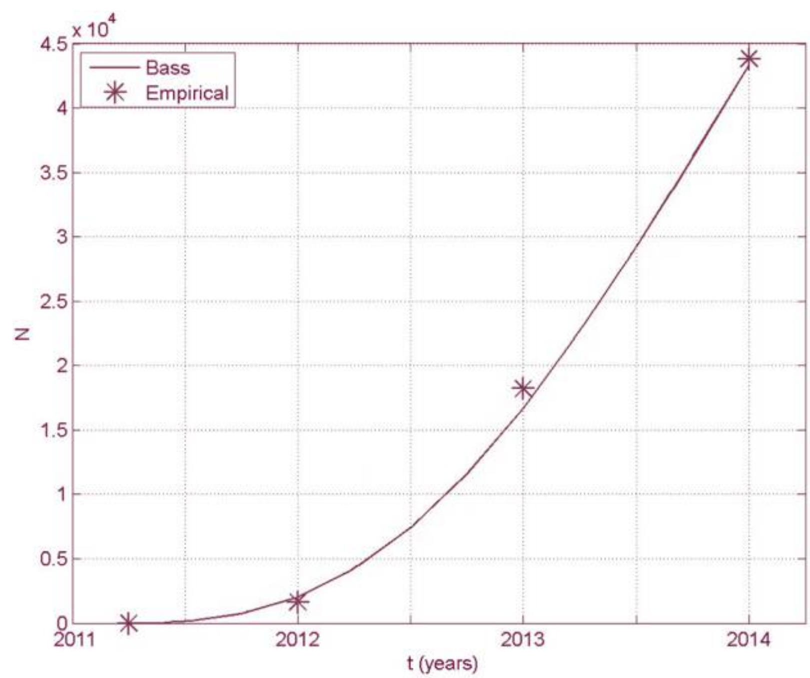
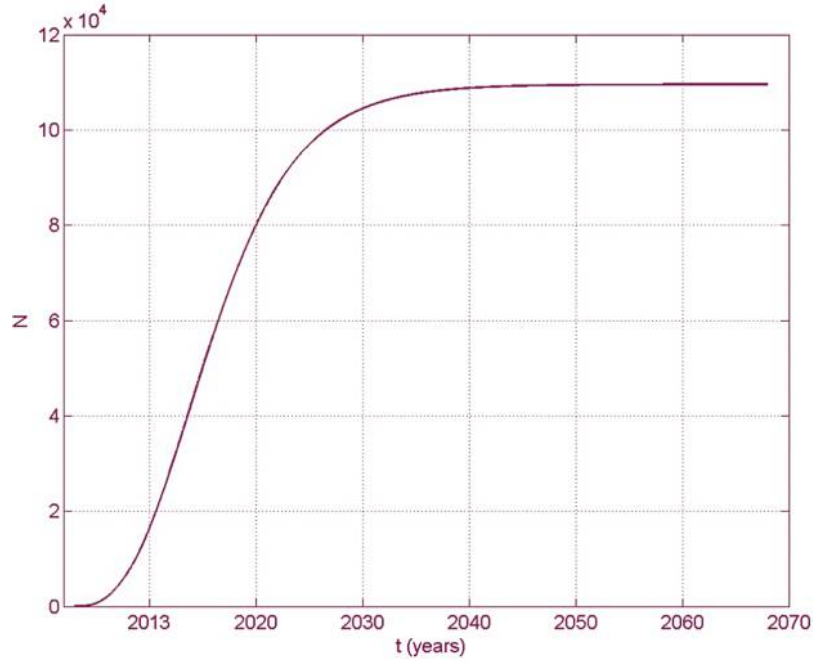


Figure 2 Uses of knowledge-sharing technologies, theoretical prediction



of knowledge-sharing technologies, like the social network or the Internet-based ones, replaced the previous network with regulated and formalized means of interaction that do not integrate existing deeper structures. A primary outcome of the adoption of the described technologies was the removal of multi-directional radio communications between driver, base and driver-network and its replacement with a highly sophisticated automated job allocation system. Therefore, drivers were no more strictly tied to their cars, sharing knowledge only when parking or queuing.

The authors have then presented a theoretical and experimental analysis of the model for the diffusion of an innovation technology that was proposed by Easingwood *et al.* (1983) and generalizes the more popular Bass model to the case of non-uniform internal influence. In particular, the authors showed that such a model, which, from the mathematical standpoint, consists of a Cauchy ordinary differential problem, has a unique solution defined for all values of time.

In addition, the authors used the model by Easingwood *et al.* (1983) to perform an empirical analysis of the Southern Italian sector of the taxi companies by focusing in particular on a sample from two of the biggest taxi brokers operating in the city of Naples. The results obtained reveal that the model considered provides an excellent agreement with the real data. In addition, the model by Easingwood *et al.* (1983) allows making interesting future predictions about the cumulative number of uses of knowledge-sharing technologies within the considered CoP.

In addition, we detailed *implications* for research in innovation diffusion modeling.

The current study introduced and confirmed that social Web tools and technological opportunities are likely to be among the latest enablers of tacit knowledge-sharing in the private transport sector.

The study documented not only the potential contributions of social platforms to facilitate tacit knowledge-sharing but also the challenges of promoting and supporting the diffusion of technological innovations by taxi companies.

The study findings may provide an opportunity for professionals to better understand the potential of employing social media platforms to maximize the cognitive benefits for the specific needs of the communities of potential adopters. These insights could be used in determining the following:

- how to adopt social media effectively according to different levels of expertise (innovators or imitators);
- how much time does this process need; and
- finally, within which context knowledge is shared.

The first limitation of the present research is certainly the use of a sample restricted to the taxi companies from only one city: future investigations should consider a larger sample by interviewing taxi companies from multiple regions as well. Another limit is that the model performed does not take into account all the factors influencing the diffusion of knowledge-sharing technologies within the CoP. Finally, the research design is not considering the impact of the diffusion of knowledge-sharing technologies on the customer relationship management: may the passengers gain advantages from a more formalized circulation of knowledge within the taxi drivers' CoP? If so, in which way? Future research may provide a response to those questions.

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