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KNOWLEDGE TRANSFER CHARACTERIZATION AMONG STAKEHOLDERS. APPLICATION TO PROJECT PORTFOLIO MONITORING IN PROJECT BASED INDUSTRIAL FIRMS

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Project management knowledge is associated with learning that occurs within projects. Reality shows that valuable knowledge and experience gained managing projects are usually lost and not applied in others. At best, lessons are shared by project team members moving on to new projects, but normally knowledge is not shared with others outside the project management office. The aim of this article is to study the characterization of the sharing best practices and lessons learned between the project management office and the other stakeholders. Based on a review of the existing literature, we analyze how knowledge transfer occurs in project based industrial firms in order to improve future project monitoring and we propose to take always into account all the stakeholders in lessons learned. ; Project managers create new knowledge and disseminate it throw all the stakeholders. Learning and teaching occur at every level of the project, so understanding the behaviour of knowledge transfer we can improve future projects control. The findings have been tested by a deep empirical research based in various companies where project knowledge learning is well established.

Keywords: *Project management; Project learning; Knowledge transfer; Stakeholders*

CARACTERIZACIÓN DE LA TRANSFERENCIA DE CONOCIMIENTO ENTRE PARTES INTERESADAS. APLICACIÓN AL CONTROL DE CARTERAS EN EMPRESAS INDUSTRIALES BASADAS EN PROYECTOS.

El conocimiento en la gestión de proyectos está asociado con el aprendizaje que tiene lugar en los propios proyectos. La realidad muestra que el conocimiento adquirido gestionando proyectos se pierde y no se aplica en otros. En el mejor de los casos, las lecciones son compartidas por los miembros del equipo de proyecto pasando a nuevos proyectos, pero normalmente el conocimiento no es compartido fuera de la oficina de gestión. El objetivo es estudiar la caracterización del intercambio de conocimiento entre la oficina de gestión del proyecto y el resto de las partes interesadas. Analizamos cómo se produce la transferencia de conocimiento en empresas industriales basadas en proyectos con el fin de mejorar la monitorización de proyectos futuros y proponemos involucrar en las lecciones aprendidas a todas las partes interesadas. Los gestores de proyectos crean nuevos conocimientos y los difunden a todos los interesados. El aprendizaje y la enseñanza se producen en todos los niveles del proyecto por lo que comprendiendo el comportamiento de la transferencia de conocimiento podemos mejorar el control de los proyectos futuros. Los resultados han sido contrastados mediante una investigación empírica basada en varias empresas donde el aprendizaje basado en proyectos está bien establecido.

Palabras clave: *Gestión de proyectos; Aprendizaje basado en proyectos; Transferencia de conocimiento; Partes interesadas*

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1. Introduction

We study the knowledge transfer and the knowledge diffusion that take place among stakeholders in the project management processes. The main definition of a stakeholder is suggested by Freeman (1984) as a person or a group of persons that have influence or that are influenced in the achievement of the project final goals. We know that the project management office has the most important role from the management point of view, but it is always influenced by the rest of the project stakeholders. Crawford, Pollack and England (2006) talk about the great effects that could have the project environment about its success. There are relevant studies about each stakeholder performance and interests, such as those carried out by Winch and Bonke (2002). There are other studies such as those carried out by Missonier and Loufrani-Fedida (2014), and Aaltonen (2011) that also analyze the stakeholders performance from the point of view of the internal relations that take place in the projects. We can see in all of them how each stakeholder performance, interests, objectives and knowledge can greatly influence in the project success. On the other hand, there are also many studies carried out by consultants, academics and practitioners with very relevant conclusions about knowledge project management. Among the most recent, we can highlight those published by Holzmann (2013), Basu (2014) and Spalek (2012).

We use and combine these studies results about stakeholder management and knowledge management to apply them to industrial companies managed by projects and to perform an analysis and a characterization of the knowledge behavior generated and disseminated by all the stakeholders.

It is obvious that each stakeholder knowledge can has a big impact on the project results. At the same time, the knowledge generated in each project can has a great impact on its development and in the future project portfolio development. The Project Management Institute (PMBOK 2017) already identifies knowledge as a new resource in the project where it becomes a critical success factor for them.

In industrial environments, companies increasingly manage more projects at the same time so, the performance characterization of the knowledge transfer and the knowledge diffusion among all the project stakeholders will be a key factor for the future projects success.

There are a lot of classifications of the project stakeholders. We are going to classify them in two important groups for the analysis that we are going to carry out in this study: the project management office figure that consists of the different members in charge of the direct project management and which they are the main managers of the knowledge traffic, and the external stakeholders which they are the rest of figures that are not directly in charge of the project management, but that they can have influence on it.

The project management office will be the facilitating unit for the knowledge transfer to the rest of the stakeholders. We recommend the use of a shared knowledge network among all the stakeholders, which we will call the knowledge transfer channel. We will see how the knowledge transfer modelling will depend on that channel characteristics.

The article is structured as follows: first, the objectives that want to be achieved are listed. Next, a brief description of the problem to be studied is given and a review is made of the state of the art. Then, the practical case study is described. Finally, the results are analyzed and the conclusions and contributions in this research work are specified.

2. Motivation

Knowledge in project management is associated with the learning that takes place in the projects themselves. The reality shows that the knowledge acquired managing projects is

lost and it does not apply in others. At best, the lessons are shared by the members of the project team moving on to new projects, but normally the knowledge is not shared outside the project management office.

The main objective of this study is the characterization of the knowledge transfer and diffusion among all the projects stakeholders carried out in industrial environments companies in order to obtain patterns or performance curves that allow us to optimize the project portfolio management. Therefore, an analysis of the knowledge exchange between the project management office and the rest of the stakeholders involved in each project will be carried out.

Project managers create new knowledge and disseminate it to all the stakeholders. We live in a world where not everyone knows everything from the beginning and in which the learning skills are not perfect. We think that it is fundamental to understand the way in which project managers generate knowledge and how they transfer it at all levels to the rest of the stakeholders. This knowledge diffusion characterization will allow us to improve the forecasts, accelerate the project optimization and achieve improvements in the project control processes.

From an empirical point of view, the model can be tested in a theoretical context through seemingly unrelated regressions that will allow us to simulate the different scenarios and the knowledge dissemination curves.

3. Problem description and literature review

Although knowledge diffusion and knowledge transfer are well established throughout the most relevant literature, the existing knowledge flow among all the project stakeholders has never been modeled. Gupta and Govindarajan (2000) study the knowledge transfer in a wide spectrum of multinational companies. Sun and Scott (2005) investigate the knowledge transfer barriers originated in the different learning levels in the companies. Von Krogh, Nonaka and Aben (2001) evaluate the way in which the knowledge creation and knowledge transfer are translated into learning from the organization successes and failures. Kenney and Gudergan (2006) investigate the knowledge integration in organizations with the purpose of empirically testing the effects of different organizational ways and capacities about the efficiency, scope and flexibility of the knowledge integration at a company level, given the influence of the knowledge types and their ways. Rivera-Batiz and Romer (1991) study the technological knowledge transfer at an organizational level. As we can see, there is great deal of talk about knowledge diffusion and human capital in organizations, but there are no knowledge transfer models that show and characterize how the knowledge is generated and shared by all stakeholders involved at a project level.

The Bass model represents the main chain of diffusion models proposed throughout the literature and it has been used as a forecasting diffusion model in different areas such as technology, industry, retail services, agriculture, education, pharmaceutical products and durable consumer goods markets (Mahajan, Muller & Wind, 2000). There are also many studies about the forecasts of the behavior new products diffusion in the market. The most cited models in the literature are those proposed by Kalish (1985), and Mahajan, Muller and Bass (1990). Chen and Chen (2007) also analyze the Bass model on the basis on dynamic systems and compare it with other models of stochastic diffusion.

Chien, Chen and Peng (2010) also propose a model based on the Bass model using a nonlinear least squares analysis forecasting methodology. Qin and Nembhard (2012) suggest two different approaches to analyze product diffusion such as the Bass model approximations and the geometric Brownian motion model. The most recent studies talk

about automatic learning algorithms and statistical approximations that are also based on the Bass model, such as the suggested by Lee et al. (2014).

The Bass model is based on the premise that the probability to buy a product is influenced by the number of previous consumers. Thus, the model is generated from the probability that a purchase will occur in the future assuming that it has not happened in the past. In this study we intend to start from this model assuming these premises and supposing that knowledge transfers always occur in stochastic environments. With this, we achieve a knowledge transfer characterization that takes place between the two groups of stakeholders specified above, to which we will add different variabilities, always assuming that we have a knowledge saturation level which defines the total knowledge reached by both of them and which will serve to optimize the current project management and the future projects management.

4. Case study

4.1 Problem modelling

Knowledge acquisition will end when the knowledge saturation level is reached from the point of view of project managers. The knowledge acquisition time is a random variable with a distribution function *F(t)* and its corresponding density function *f(t)*, which represents the probability of acquiring knowledge, so that the diffusion process as a function of time can be written as the equation 1.

$$\frac{dF(t)}{dt} = f(t) = [p + qF(t)][1 - F(t)] \quad (1)$$

The time rate [*p*+*qF(t)*] is the stakeholders fraction that have not yet acquired knowledge at time *t,* and [1-*F(t)*] is the potential stakeholders fraction that can acquire knowledge. When $p \rightarrow 0$, the knowledge diffusion process depends on internal factors, whereas if $q \rightarrow 0$, the diffusion process depends only on the external influence.

In order to achieve a practical application, the differential equation discretization is performed by the Euler method to obtain a discrete time differential equation, as we can see in the equation 2.

$$N(t) = N(t-1) + \left[p + q\frac{N(t-1)}{m} \right][m - N(t-1)] \quad (2)$$

We add a heterogeneous group of stakeholders to the model and we include the effects of the knowledge transfer channel, which will not be symmetric: external stakeholders can benefit from the information about the project management office knowledge acquisition. Thus, we will obtain different knowledge acquisition curves. The shape of the curve only depends on the ease of knowledge transfer. The easier it is, the faster will be the knowledge diffusion and there will be a lower probability to have a greater distance between the first and the last parts of the curve.

If we assume that all the variables are well known, we can perform the model characterization from a deterministic point of view. We call *N(t)* the stakeholders, which are separated into groups, $N(t)_k$, with k=1 will be the project management office, and with k=2 will be the external stakeholders. By definition, the project management office members are the first to acquire knowledge. We include the parameter $q_{12} \in \{0,1\}$ in the model, which indicates the communication probability among the two stakeholder groups within the knowledge exchange channel.

We add these variables to the model, obtaining equations 3 and 4, which describe the knowledge diffusion process for the project management office and the external stakeholders, respectively.

$$\frac{dN_1}{dt} = \left[p_1 + \left(q_1 \frac{N_1}{m_1} \right) \right] [m_1 - N_1] \tag{3}$$

$$\frac{dN_2}{dt} = \left[p_2 + \left(q_2 \frac{N_2}{(m_1 + m_2)} \right) + \left(q_{12} \frac{N_1}{(m_1 + m_2)} \right) \right] [m_2 - N_2] \tag{4}$$

If q_{12}=0, the project management office and the external stakeholders acquisitions are independent from one other. If we make a matrix study, the first element of the diagonal is zero and we have an upper triangular matrix, which indicates that the information flow is asymmetric.

We assume that the derivatives of each group exist and create a single stationary vector with N_1 and N_2. There is an equilibrium when dN_1/dt=0. Thus, if m_1=N, then dN_1/dt=0. Here, the project management office members that have acquired knowledge have reached the saturation level m_1, in other words, every project management office potential member has acquired new knowledge. So, if m_2=N_2, dN_2/dt=0, it implies that the external stakeholders members have reached the saturation level m_2. The equilibrium is reached when both, the project management office and the external stakeholders reach their specific knowledge saturation levels, in other words, when N_1=m_1 y N_2=m_2.

We know that the uncertainty will not be constant over time, so there will be greater fluctuations around the S curve inflection point that defines the knowledge diffusion path. Thus, based on the Boswijk and Franses (2005) models, we can add randomness to the model characterization if we consider the cumulative number of project management office members and external stakeholders members as random variables.

4.2 Methodology

An empirical investigation has been carried out, where we have obtained a long data capture from which the parameters values that characterize the model have been stablished. The study has been carried out in 23 industrial companies where project based learning is well established. All of them belong to the industrial field and they are from 4 different countries. A questionnaire has been developed and their answers have been defined face to face with the project management office members of each of the analyzed companies. This questionnaire has been tested and it has been studied internally as a pilot with the project management office of one of the companies which have participated in the study. We have obtained satisfactory results, so we have applied the same questionnaire to the rest of the companies. We have registered 276 answers during a 36 week work period and we have held face to face meetings to obtain as reliable as possible results in all of the companies.

A first qualitative validation was carried out by an expert for each of the companies analyzed. Subsequently, a validation for all the stakeholders was developed. To do this, the same survey was proposed with two different Likert scales, a first one of 7 points that was applied to the project management office members and a second one of 5 points that was applied to the external stakeholders identified in each of the projects. A statistical analysis was carried out after obtaining the final general consensus about the pilot questions and results and finally, we proceeded to determine the study reliability by means of a statistical calculation of the Cronbach's alpha coefficient.

We have obtain the parameter values of the model that we want to characterize so, we analyze the difficulty or ease in the knowledge diffusion and the knowledge transfer from the project management office point of view and from the external stakeholders point of view. We define the m_1 and m_2 parameters as the knowledge saturation levels, where both the project management office and the external stakeholders have acquired all the necessary knowledge to optimize the current project management and future projects. The knowledge transfer channel is also evaluated to know if it is suitable, that is, to see what is the communication probability between the project management office and the external stakeholders so that the knowledge exchange takes place. For this analysis we define the parameter q_{12}. The probability of acquiring knowledge at a point t of the project is also calculated when there is influence of project external factors. In this case, we define the knowledge transfer coefficients p_1 and p_2, referenced to the project management office and the external stakeholders, respectively. The probability of acquiring knowledge throughout the project when it depends on internal factors is also studied. We define now the knowledge transfer coefficients q_1 and q_2, referenced also to the project management office and the external stakeholders, respectively.

5. Results and validation

A characteristic of the proposed model is that it can be directly estimated by a seemingly unrelated regression approximation, which allows us to use the simulation to validate possible scenarios. In order to simulate the continuous system resulting, we use the Euler-Maruyama approximation, obtaining in this way discrete knowledge acquisition approaches in each interval.

As a result of the study, the parameters summarized in table 1 are set.

Table 1: Parameter values obtained in the qualitative study

Parameter	Value
m_1	1.00
m_2	1.00
q_{12}	0.10
q_1	0.75
q_2	0.25
p_1	0.20
p_2	0.05

Saturation levels are set as m_1=1 and m_2=1, considering that all the possible knowledge has been acquired to allow an improvement in the project management. The coefficient q_{12}=0.1 indicates that the knowledge exchange probability between the project management office and the external stakeholders is low, that is, the knowledge transfer channel established is not adequate. The transfer coefficients due to project internal factors are set as q_1=0.75 *and* q_2=0.25, which means that the probability of acquiring knowledge by the project management office is three times greater than the probability to do the same by the external stakeholders. The coefficients p_1=0.20 and p_2=0.05 indicate that the probability of acquiring knowledge by external influence is four times higher in the case of the project management office. Even so, the probability is low if we compare them with the previous coefficients.

The questionnaire evaluation by the experts of each of the project management office was satisfactory, which helped in the search for the results usefulness. As we seen before, an

analysis of the questionnaire reliability and validity was carried out by calculating Cronbach's alpha coefficient. In this case, the answers homogeneity is acceptable for the two scales applied, obtaining a questionnaire reliability index with a value of alpha of 0.708, for the case of the 7 points scale, and with a value of alpha of 0.676 for the case of the 5 points scale. We consider both results acceptable and consistent. The reliability analysis is summarized in tables 2 and 3.

Table 2: Mean, Variance and Cronbach's Alpha with a 5-point Likert scale

	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Q.11	Q.12	Q.13
Mean	3.696	3.217	3.304	3.217	3.435	3.043	3.739	2.826	3.870	2.739	2.478	3.043	2.652
Var.	1.310	1.630	1.580	1.090	1.260	1.320	1.020	1.700	1.480	1.380	1.900	1.860	1.870
Alpha	0.763												

Table 3: Mean, Variance and Cronbach's Alpha with a 7-point Likert scale

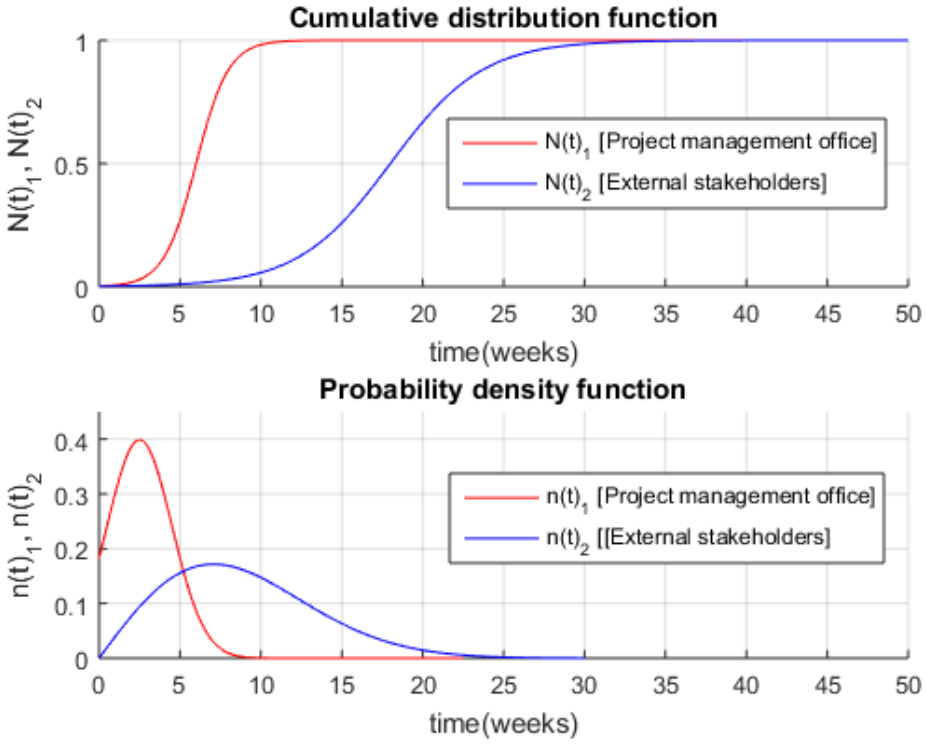
	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Q.11	Q.12	Q.13
Mean	4.435	3.826	5.043	3.652	3.739	3.130	3.783	3.478	4.043	2.913	3.348	3.435	3.522
Var.	1.800	1.330	2.410	1.420	1.750	1.300	2.000	2.080	2.230	1.900	2.240	2.440	2.260
Alpha	0.815												

We performed a simulation of the model acquisition curves with the parameters obtained in the qualitative study considering a limited knowledge transfer with q_{12}=0.1 as the most expected value obtained in the study. The upper graph of figure 1 illustrates the diffusion process for $N(t)_1$ and $N(t)_2$, that is, for the project management office and the external stakeholders, respectively. We can observe how the knowledge diffusion process of the project management office is nearing its end in approximately 12 weeks because all the members of the project management office have acquired new knowledge, that is, $m_1=N(12)_1=1$ and therefore $N(t)_1=0$. On the contrary, the knowledge diffusion process of the external stakeholders ends in about 36 weeks with $m_2=N(36)_2=1$ and therefore $N(t)_2=0$.

The lower chart of figure 1 represents the knowledge transfer density function. It is a unimodal distribution that tends to the right side. This is because the project management office members have acquired all the knowledge and they have made the inflection point, while the external stakeholders have just started the knowledge acquisition.

In order to obtain a family of curves that define the knowledge transfer performance among stakeholders, the initial parameters of table 1 have been applied to the defined model differential equations. The simulations show us how the changes in the q_{12} parameter, which defines the knowledge transfer probability, affect to the system, and it also show us how knowledge transfer variations affect the model accumulation and acquisition curves for all the stakeholders. The simulations results are illustrated in figures 2, 3 and 4.

Figure 1: Stakeholders knowledge diffusion process (q_{12}=0.10)



In the upper graph of figures 2, 3 and 4 we can observe the distribution functions $F(t)_1$ and $F(t)_2$ of the project management office acquisition process and of the external stakeholders acquisition process, respectively. We can also observe the discrete approximation of the distribution functions expressed as $N(t)_1/m_1$ and $N(t)_2/m_2$, respectively and with m_1=1 and m_2=2. The distribution function presents a pattern close to a S curve. In the lower graphs of figures 2, 3 and 4 the approximations of the density functions $f(t)_1$ and $f(t)_2$ are represented for the acquisition processes of the project management office members and the external stakeholders, respectively.

Next, we analyze the results of the three scenarios studied: in the first one, it is assumed that the knowledge transfer from the project management office members to the external stakeholders is almost forbidden, coinciding with q_{12}=0. The result is illustrated in figure 2. We recall that the knowledge transfer process is asymmetric, which means that the knowledge transfer goes from the project management office members to the group of the external stakeholders and not vice versa. The second scenario is characterized by a limited knowledge transfer, with q_{12}=0.1, which corresponds to the simulation illustrated in figure 3. The last scenario is illustrated in figure 4, where a nearly complete knowledge transfer is assumed, which means that there is a well defined knowledge transfer channel. In this case, we have q_{12}=1.

Figure 2: Stakeholders new knowledge diffusion process (q_{12}=0.00)

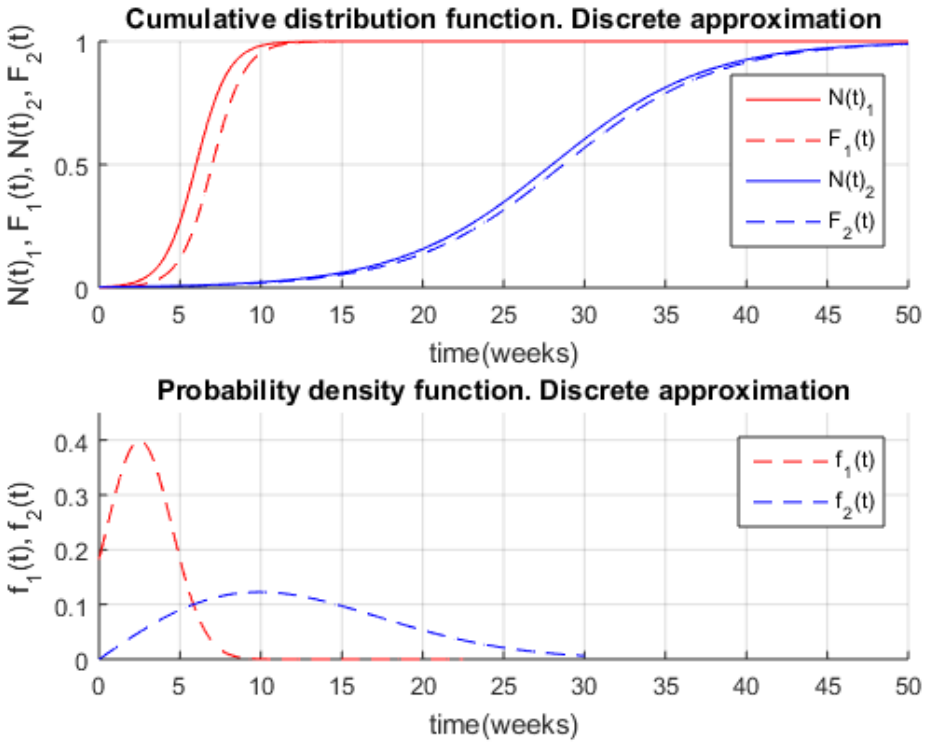


Figure 3: Stakeholders new knowledge diffusion process (q_{12}=0.10)

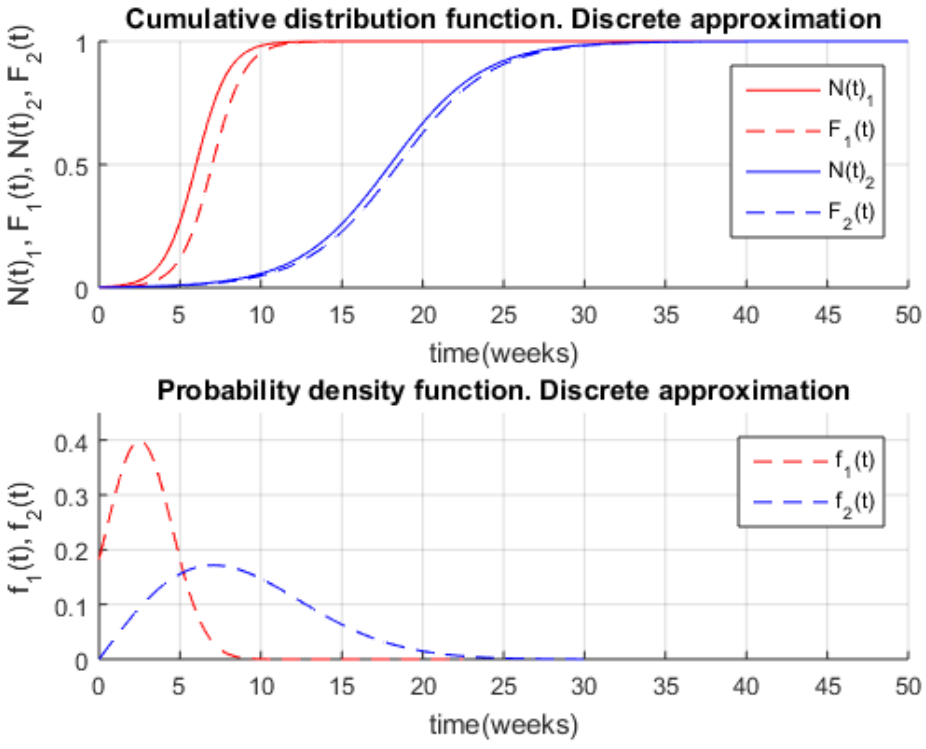
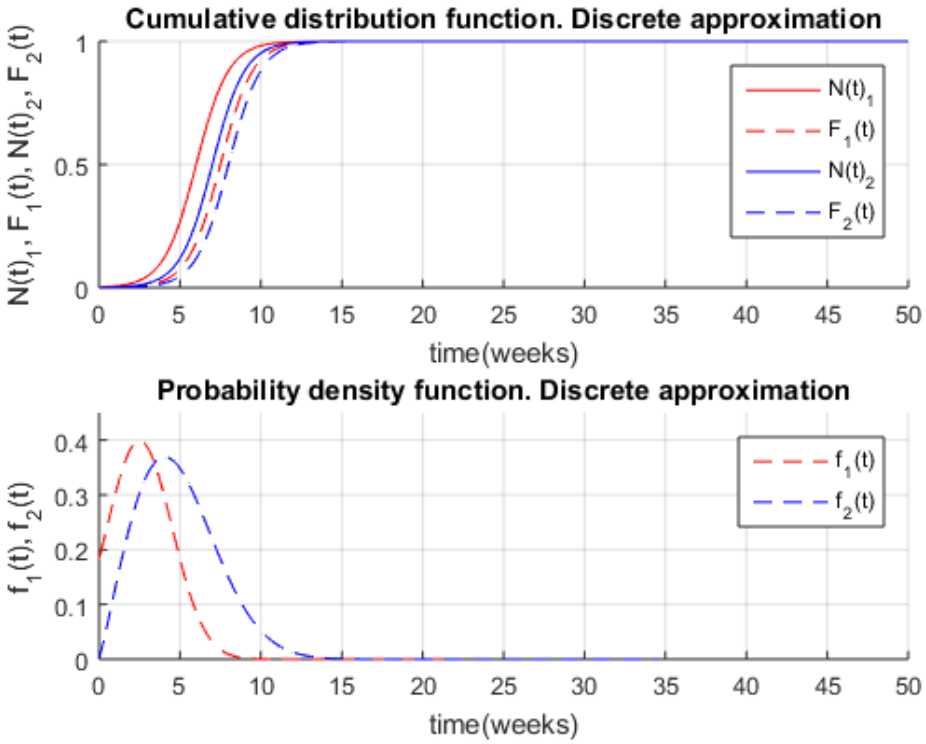


Figure 4: Stakeholders new knowledge diffusion process (q_{12}=1.00)



Analyzing the simulations carried out, we can conclude with the following statement: when the knowledge transfer channel is not well defined, that is, if $q_{12}\rightarrow 0$, the greater the discrepancy between the realization of the inflection point of the project management office members and the beginning of knowledge acquisition of the external stakeholders, the clearer acquisition curve with a bias to the right is seen. On the other hand, if there is a well established and a well defined knowledge transfer channel, the parameter q_{12} will be larger. Before the project management office members have made the inflection point, the external stakeholders have almost reached their inflection point. In this way, we can conclude that there will be a bell shaped pattern biased to the right if there is hardly any knowledge transfer channel, and on the other hand a symmetrical pattern will be more likely if the transfer channel is well established.

6. Discussion and Conclusions

6.1 Findings and implications

The relationships between the knowledge transfer and their channel effects among all the project stakeholders have been studied. The question of how knowledge transfer influences the knowledge acquisition performance of all stakeholders, where the most relevant literature had not put focus, has been answered. In this way, we can know if we need to improve the knowledge transfer channel depending on the knowledge dissemination curve bias, in order to achieve a stakeholder's knowledge acquisition optimization and to have the possibility to benefit from it in other projects of the company global portfolio.

We have also seen how the knowledge diffusion path takes an S curve shape, and its definition will depend on whether the knowledge transfer channel among all the stakeholders is well stablished or not.

Another important finding is that we have seen that there is greater uncertainty in the knowledge transfer at the beginning and at the half way of the diffusion process than at the end of the process.

On a methodological point of view, this research is a contribution to an improvement project control framework, and on a practical point of view, it could help project managers to achieve the goals set managing and optimizing the global portfolio.

6.2 Limitations of the study

As we have mentioned previously, one of the model limitation is that the knowledge acquisition curves present a typical S curve pattern. This is because we are assuming that the diffusion process has only one direction, always considering the project management office as the project knowledge source.

Another limitation, from the point of view of the empirical analysis, is that the questionnaire has been based on the experimentation that has taken place in small and medium companies, where there is an open and flexible organizational culture that allows face to face communication, which helps to share and spread knowledge in a successful way. We don't know how the knowledge diffusion could perform in large companies where the communication channels and knowledge transfer among stakeholders, despite being well established, may have different characteristics. Presumably, the initial parameters calculated would have variations, so we would have different curves with respect to the model characterized in this study.

We are assuming consistent over time knowledge saturation levels, which is very strict assumption since there may be variability caused by the risks and by the changes inherent in the project.

6.3 Concluding remarks and future research

There are several revenues for further research. For instance, it is planned to calculate a series of curves that can define typical projects in a project based company, and that can help to manage future projects with similar characteristics, where the tools, the processes and the stakeholders are often repetitive, taking advantage of information obtained in past projects in order that project managers can optimize more the project portfolio.

We can also add variability caused by project risks to the study and recalculate the initial parameters to show possible differences between types of risks. It is also possible that there is a relationship between the knowledge transfer channel improvement and risks control.

Among the many possible directions for future work, the possibility to integrate the results obtained in the study with project monitoring techniques such as earned value management, results particularly intriguing, in order to value if an increase in efficiency and a tasks control improvement can be obtained.

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