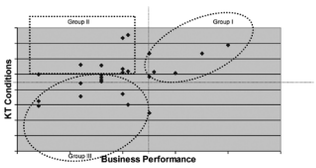
Competitiveness of basque high-tech firms induced by knowledge transfer conditions: multivariate data analysis empirical research



Competitividad de las empresas vascas de alta tecnología en relación con sus condiciones para la transferencia de conocimiento: estudio empírico basado en análisis multivariante

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RESUMEN

• La transferencia de conocimiento (TC) en un complejo fenómeno relacionado con el desarrollo de innovaciones y con el éxito empresarial gracias a la mejora de competitividad de la empresa, lo cual es especialmente relevante en el caso de empresas de alta tecnología cuya viabilidad depende del eficiente manejo de sus activos de conocimiento. Trazar la conexión existente entre la dinámica de TC y los parámetros de competitividad empresarial es una línea de investigación con grandes posibilidades de contribución a una mejor gestión empresarial. Esta investigación pretende demostrar empíricamente que el capital intelectual y el capital económico de una organización de alta tecnología se incrementan de forma relevante gracias a una óptima gestión de la TC realizada durante un periodo de tiempo sostenido. Siguiendo una metodología de investigación empírica se realiza una encuesta entre empresas de fabricación y desarrollo de alta tecnología en la comunidad autónoma vasca cuyas respuestas se procesan mediante técnicas de análisis multi-variante. Los resultados prueban que la existencia de características organizativas y mecanismos aptos para la TC no asegura por si mismo un mejor desempeño empresarial ya que los mecanismos deben estar adecuadamente diseñados e implantados. Sin embargo, la carencia de condiciones adecuadas para la TC si aboca a un pobre rendimiento y falta de competitividad, implicando que estas organizaciones deben considerar la gestión de la TC como una herramienta de estrategia empresarial. Así mismo, el estudio evidencia desorientación entre las empresas a la hora de estructurar y organizar la dinámica de TC, y la existencia de una probabilidad menor al 50% para que una organización de alta tecnología comprometida con la innovación opere correctamente y se esté beneficiando de la TC. Por tanto, otra implicación radica en que las políticas públicas y los agentes facilitadores deben aportar soluciones de sensibilización, comprensión y fomento.

• **Palabras Clave:** Transferencia de conocimiento, competitividad, empresas de alta tecnología, rendimiento del negocio, mecanismos y atributos para la transferencia de conocimiento.

ABSTRACT

Knowledge transfer (KT) is a phenomenon linked to business performance particularly relevant for high-tech companies whose viability depends on characteristics and handling of knowledge assets. Tracing connection between KT dynamics and competitiveness is a current field of research which should be tackled with more extensiveness with the final purpose of bringing to light the keys for more efficient business management and a fair social and economic development. This research aims to demonstrate empirically that there is compelling evidence of such engagement, and that the intellectual and financial capital of a high-tech firm is sharply increased thanks to the efficient management of the global phenomenon of KT along a sustained period of time. Following a methodology based on a quantitative research approach, we carry out a survey among manufacturing and development high-tech companies in the Basque region of Spain in order to execute data mining processes with the answers using techniques of multi-variant analysis. The results obtained let us prove that the sheer existence of suitable organizational features and mechanisms for KT does not entail a better business performance, since the KT mechanisms must be properly designed, implemented and operated. However, the lack of appropriate conditions for KT does speed the organization towards an underperforming stage with consequent loss of competitiveness. The research results also show a clear disorientation of the companies when it comes to plan, structure, organize and operate KT dynamics, with the finding that a company committed to innovation has actually a chance of less than 50% of being successful by leveraging the power of KT when translating it to business performance. Implications can be laid: high-tech entities should take in and adopt practices for efficient KT as part of the business strategy, and public policies and other stakeholders should provide awareness, understanding, and encouragement on the issue

Key Words: Knowledge transfer, competitiveness, high-tech firms, business performance, knowledge transfer attributes and mechanisms.

1. INTRODUCTION

Knowledge transfer (KT) corresponds to the phenomenon of internal and external flows of knowledge being operated within a single unit or a network of organizational units [1, 2, 3] It can be explained thanks to the theories of resource-based view of the firm [4, 5, 6, 7] and knowledge-based view of the firm [8, 9, 10]. According to their postulates, enterprise resources moderate the growth and business performance of the organization [11] since it could be regarded and analyzed as a set of resources [4, 7] whose successful management [5, 6] entails competitive advantages. The efficient management of knowledge assets – strategic resource [11] - is the core issue of the second theory, resulting in the com-

petitive advantage of the firm, and it is crucial for improvement [9, 10]. Hence the business performance depends on the integration of the knowledge assets into the business processes, namely, the combination and coordination of knowledge at the organizational level, developing capabilities, and enabling decisions [12]. There is a virtuous circular relationship between knowledge and capabilities, since generating new knowledge involves the development of capacities which leads again to the creation of the former [13]. In summary, these theories set that performance of a firm depends on its organizational skills, abilities and knowledge [11] composing a repository and characterizing the company which, as long as it is properly managed, enables a competitive advantage over its competitors [14].

In particular, high technology companies are strongly rewarded by the impact of a suitable dynamic of KT, because not only does it enable the creation and development of skills, technological capabilities, and innovative goods and services [15, 16, 17, 18, 19], but it also influences their business performance, competitiveness, sustainability and viability [20, 21, 22, 23, 2, 24, 25, 26]. The characteristics of high-tech firms are unique and quite different to other entities because range of technological intensity is the uppermost demanding [17, 18].

This research aims to validate empirically that entities holding optimal KT dynamics outstand in Business Performance (BP) due to the positive effects of Impact of KT executed (IKT). Thus, these companies are more sustainable and competitive. Since KT could be framed and described trough an array of factors (F) which moderate its impact, we can formulate that:

$$IKT = f(F_1, \ldots, F_N).$$

Then, we can proceed with the design of a survey enabling the acquisition and analysis of the data and deducing the extent of compliance of the firm, then, identifying the dynamics of KT operated by the company. Afterwards, we can correlate the results obtained and the enterprise performance indicators in order to verify our hypothesis:

$$BP = f(F_1, \ldots, F_N), \text{ where f is an increasing function.}$$

2. METHODS AND TOOLS

We build this methodology with the objective of disclosing the relation between KT dynamics and its degree of competitiveness:

a) Selection of a model representing the KT phenomenon through business factors, and encapsulation of variables into a questionnaire.

b) Identification of the sample to be surveyed.

c) Implementation of the survey process, capturing and processing data using multivariate statistical analysis.

We appoint to surveymonkey.com as the electronic platform for web survey given its suitability for this type of work [27]. IBM SPSS is selected for data analysis since it has been widely used for analogue thematic research [28, 29].

2.1 KNOWLEDGE TRANSFER MODEL AND ENCAPSULATION OF VARIABLES

Models representing the socioeconomic phenomenon of transferring knowledge pretend to describe the complex flows of knowledge and relationships among participants in order to frame a theory allowing the addressing of issues and improving business and administration of the organisation [30]. In fact, these models aim to supply a greater understanding on its structure, outcomes, and implications. Models let us study the connection among management of KT, impact caused by systematic KT processes, and degree of competitiveness achieved. Determining factors of impact influence on the KT dynamics by leading it towards certain results; so, they moderate the impact, affecting the viability of the organization. Hence, the starting point of the research is the selection of a business model representing comprehensibly the phenomenon from a holistic point of view. The selected model is called "contingency effectiveness model of technology transfer" [15], amended later by the author in the "revised contingent effectiveness model of technology transfer" [19]. Well-known and globally accepted model, it exhibits a suitable abstraction scale in order to remain represented all types of KT events and results, letting researches and practitioners study KT for diverse sciences branches. In fact, it has been numberless used by researches on this issue, and handled for applications, or, as a conceptual framework in a wide variety of articles, ranging from ecology or higher education to health. The author himself expresses this fact in: "Technology Transfer Research and Evaluation: Implications for Federal Laboratory Practice, Final Report to VNS Group, Inc. and the U.S. National Institute of Standards, April 4, 2013". Thanks to this model we can research on the factors whose characterization

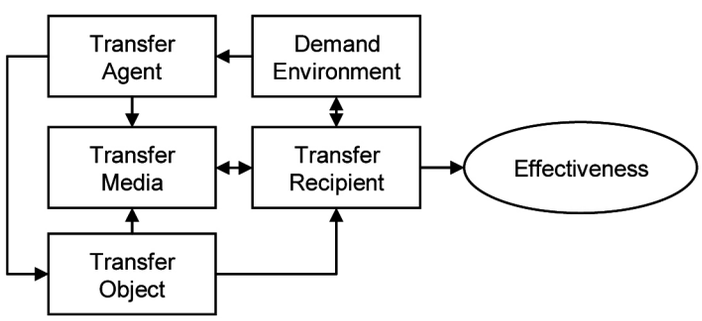

Fig.1: Contingent effectiveness model of technology transfer [15, 19]

has influence in the celebration of KT, and consequently, impact on the final outcomes obtained (Fig. 1).

On the other hand, factors of KT impact can be classified into two groups: attributes and mechanisms [15, 25, 31]. The former act as quasi-static parameters during the performance of KT events because they keep fixed or slightly change in a mid or long term owed to the influence of the last, called controlled variables, since they can be manipulated by people in charge of the phenomenon. The results of KT may be assessed according to the KT impact achieved and related to the initial goals. Mathematical abstraction of the model would be:

$$IKT = f(A, M) = f(A_{NC}, A_C, M),$$

As well, KT impact is consequence of attributes (A), non-controllable (A_{NC}) and controllable (A_C), and mechanisms (M), with a double success key: a proper design (d), and a suitable implementation and operation (i), namely, a KT mechanism is effective as long as it is designed, implemented and operated correctly. So:

$$m = d(m) * i(m), \text{ and, } M = \Sigma m.$$

Then, the whole outcome of KT phenomenon is dependent on its full dynamics:

$$IKT = f(A_{NC}, A_C, d(\Sigma m) * i(\Sigma m)).$$

We build a questionnaire with tabulated answers according to scales in order to enable respondents' feedback and the subsequent treatment of the acquired data. First set of questions (A) aims to gauge the grade of competitiveness of the company, and second (B) and third (C) seek to understand KT dynamics. Dependent and independent variables are firstly defined, and later enclosed into them (Fig. 2):

Dependent variables are descriptors of the degree of business performance measured thanks to diverse set of indicators [32, 33, 34, 35, 36]. According to [33], we must regard six dimensions. Meanwhile, [32] sets three parameters exposing business performance. Likewise, [36] explains that the performance of high-tech companies should be studied by both financial and non-financial indicators. Finally, [34] and [35] proclaim that intellectual capital is a main parameter of business performance, so that intellectual capital eventually has an effect on the financial capital of the company.

Taking into consideration these theoretical foundations, we establish that business performance should be studied in terms of: i) intellectual capital; and, ii) economic and financial capital. The variable framing i) will be measured by: a) human capital (A.1), as the evolution and range of intellectuality of the staff, and b) innovation and structural capital, as the rise of the intangible assets of the firm (A.2). Additionally, we set that ii) should be gauged through: a) growth of sales and revenues (A.3), and b) increase of profits or decrease of losses (A.4).

Independent variables are descriptors of KT determinants exhibited in the model, i.e., external context (B.1), complexity of the object of knowledge (B.2), attributes of the actors and their relationships (B.3, B.4, B.5, B.6, B.7, B.8, B.9, B.10, B.11), characteristics of the mechanisms of means (C.1, C.2 C.3, C.4), and characteristics of the mechanisms of strategy and corporate management (C.5, C.6, C.7, C.8).

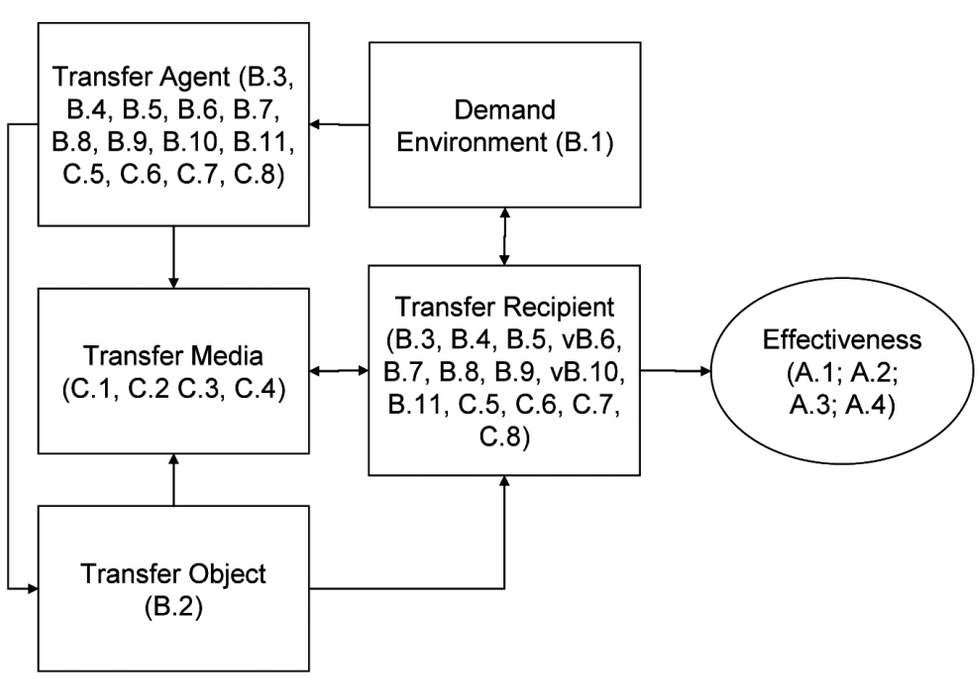

Fig. 2: KT model and encapsulation of variables for the empirical research

2.2 POPULATION AND SURVEY SAMPLE

We impose that population to be inquired is high-tech industries located in the Basque Country, Spain. According to international classification of economic activities (OECD) and Basque statistics agency EUSTAT, in the region, high-tech companies belong to: aeronautics and space, biotechnology and pharmaceuticals, electronic and information technologies, and scientific instrumentation. In addition, Basque region is characterized for the existence of industry associations representing business interests of companies, and range of adhered organisations is broad, comprising three different sorts of organisations: i) domestic manufacturing and development firms; ii) domestic companies based on knowledge-intensive business services, and iii) subsidiaries of translational companies. Our research scope is restricted to the first kind of entities, so drawing upon their data about, and adding an ensemble of high-tech start-ups created within the university environment in the region, we set forth the survey sample.

On the other hand, our study tries to ensure a confidence level of .05 with a margin of error or confidence interval of. 05, so +/- 5% sampling error with a statistical confidence level of 95% (in the worst case, where p = q = 0.5). We also need to ensure that sample of individuals represents homogeneously the existing subsectors in the Basque region. This assumption forces us to capture data in the closest proportion possible to the representation of each subsector along the total population. According to the information collected, the following is the respective weight of each subsector: aerospace type, 20%; biotechnology, 15%, and electronic and information technologies, 65%.

2.3 MULTIVARIATE STATISTICAL ANALYSIS

The multivariate statistical analysis method lets us analyze, by statistical processing of quantitative data, the information recorded thanks to the survey process. The technique is particularly suitable for a research seeking to widen the basis of knowledge on a certain topic, in order to describe the causality of that phenomenon in relation to its composing elements [37, 38]. We are dealing with KT phenomenon, characterized by a multifactorial nature, and as a result of this, any model for its representation will display multiple variables. Thus, studying its dynamics entails a multivariate analysis to enable the examination of the relationship among correlated variables, or among sets of dependent variables [39].

The replies to the questions are recorded and encoded in a database, each one divided into several registers. Questions A, B and C are codified into an intensity value since they are related to KT conditions and competitiveness: i) business results (A is subdivided into A.1 to A.4); ii) characterization of the KT dynamics (B is divided into B.1 to B.11); and iii) implementation and operation of KT mechanisms (C is divided into C.1 to C.8). In order to run the statistical analysis, the replies to

questions will be codified according to an incremental succession of values.

Then, structure of the database for the research is: i) responses about the extent of business performance of the company are 4 dependent variables located in the columns A.1 to A.4; and ii) answers about the conditions of KT dynamics are 19 independent variables which correspond to columns B.1 to B.11 and C.1 to C.8. Thanks to the multivariate analysis we will be able to find the connection between independent and dependent variables, and, according to our hypothesis, the higher range of independent variables (i.e., responses such as "very high" or "high"), the higher result of dependent variables (i.e., replies such as "sharp increase" or "moderate increase"). This way, our analysis wishes to reveal the existing relationship between variables B and C (KT dynamics) and variables A (business performance).

3. RESULTS

Once research process is finished, results of the survey will be reliable with a probability of 95% and sampling error higher than .05, so implication rises due to sample size [40]. Additionally, we obtained a distribution of replies close to the relative composition of the high technology industry in the region. As a result of this, and considering that dependent and independent variables are interval scale metrics, we proceed to perform a multivariate statistical analysis of the data as valid method.

Firstly we profile a portrait of the KT phenomenon in the high tech segment:

- 23% of questioned companies confirm that their core business is the execution of R&D activities, 30% says it is professional services related to high tech goods, 28% replies it is manufacturing high technology, and 19% claims it is delivering projects based on high technology solutions. The last figure could be split into: 25% handling in-home developed high-tech goods, and 75% working on both self-developed and third parties goods.

- 53% of the companies' sample acknowledges having a workforce with prevalence of technical and production profiles, 27% with scientific and technological profiles, 7% with business profiles, and 13% admits a balanced staff for the mentioned profiles.

- 39% of the surveyed firms declare they perform systematic intra-organizational KT operations, while 59% mentions inter-organizational operations, and 2% reports not being aware of performing KT. More specifically, out of all inquired companies, 25% admits running intra-organizational KT along the domestic environment, with up to 14% operating in a global context. Likewise, 25% celebrates inter-organizational KT with R&D objectives, 16% for manufacturing and development goals, and 18% for commercial and business development purposes.

Then, we compute statistical analysis of classification of variables and double cluster analysis according to two techniques: hierarchical based on Ward's method, and K-means, in both cases reaching the following results: 3 differentiated groupings owning a similar number of individuals (Fig. 3):

I. a group (I) showing high values of business performance (high P6 data) and high levels of conditioning factors for KT (high P7 and P8 data) (32% of the sample);

II. a group (II) displaying low values of business performance (low P6 data) and high levels of conditioning factors for KT (high P7 and P8 data) (37% of the surveyed firms);

III. a group (III) exposing low values of business performance (low P6 data) and low levels of conditioning factors for KT (low P7 and P8 data) (31% of the population).

In summary, we attain the similar outcome whatever the method of classification. That is, all the cases can be allocated into any of the three groups pertaining to their approach to KT and their extent of competitiveness, and the possibility of belonging to any of them is almost equal. Figure 2 shows the dispersion of the individuals along the coordinate plane, where horizontal axe is representing business performance of each company and vertical axe is showing their KT conditions.

4. DISCUSION AND IMPLICATIONS

Basque high-tech firms are characterized by small size, constrained turnover and small workforce, with scarce representation of corporations with the headquarters in the region. Framing the results by sub-sector, aerospace industry concentrates the larger companies, whilst biotechnology and ICT mainly encompass medium or small firms. These facts influence on: a) effectiveness of the R&D activities; b) range of absorption and adoption of external knowledge; and c) ability to turn knowledge into successful innovations.

There is a balanced distribution of the main mission of the these companies, highlighting that very few work on operations based on self-developed technologies. Furthermore, delivery of professional services is the core business for them, proving that: a) they keep on early stages of business maturation; and b) they are prone to handle third parties´ technology and, thus, running businesses with low barriers for the entry of competition. It is startling that many of surveyed companies acknowledge that providing high-tech related services is their prime mission, since we restricted our research to organizations manufacturing or developing high-tech goods, though, we also collected firms collat-

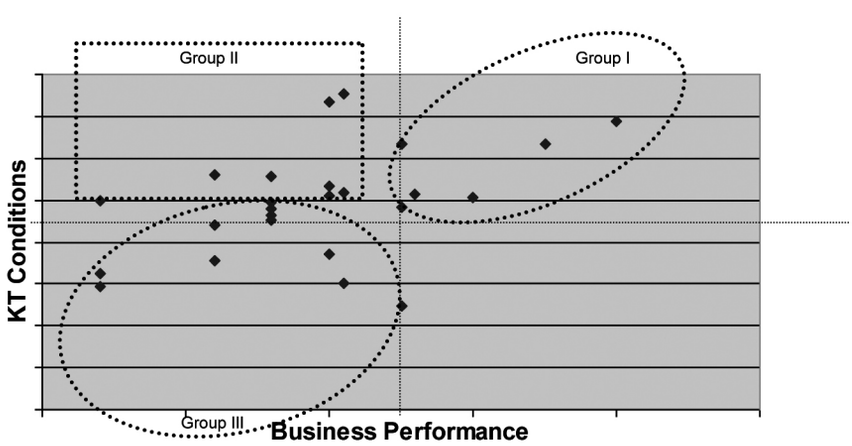

Fig.3: Sorting individuals into groupings with similar behaviour according to classification analysis technique

erally providing services related to such goods. However, despite our harsh filtering, many of the companies have reported being primarily focused on the provision of services, portraying a light grade of robustness.

The composition of the workforce of the firms reveals there is a cultural and organisational trend to hire professionals with competencies in the field of manufacturing and production, so they are more sensitive to carry out activities of production and delivery of products, services and projects, rather than being committed to R&D, marketing, commercial and business development. In fact, the rate of professionals with profiles related to R&D and business development is less frequent, remarking that the companies are meant to face a risk in the mid and long-term linked to: a) shortage of internal knowledge development (connected to development of both own capacities and marketable goods), and, b) lack of a successful commercial strategy for the results of R&D and innovation.

In a positive way, almost all surveyed high-tech companies are aware of KT as a strategy matter due to the impact on business performance. Hence, they set procedures and deploy tools to manage and perform KT operations. Still, it can be noticed a clear lack of balance between KT intra- and an inter-organizational approach. As well, there is compelling evidence regarding the imbalance of the goals for the diverse purposes of the inter-organisational KT. In fact, very few companies report a comprehensive strategy for KT, or what is more, scarce firms are really aware about the full scope of KT in its own organization and its powerful potential.

Group I show a common behaviour about conditions for KT and business performance indicators as hypothesized. However, this relation is not always a growing function, since Group II corresponds to companies which also own suitable KT dynamics, so business performance outcomes are expected to reach the top level but due to several causes they fail in accomplishing such objectives. We can ponder over the following reasons: wrong KT strategy; unsuitable management of KT operations; or, inefficient utilization of resources and capacities to perform KT. Definitely, these organizations have designed and / or implemented and operated KT mechanisms in an insufficient or inadequate way. So, taking back the mathematical formulation for the phenomenon above described:

In case of d (Σm) $\rightarrow$ 0 or i (Σm) $\rightarrow$ 0, then IKT = f (A_{NC}, A_C, d (Σm) * i (Σm)) $\rightarrow$ 0, so, IKT $\rightarrow$ 0, and then, BP $\rightarrow$ 0 and C $\rightarrow$ 0.

On the other hand, the conduct of the individuals clustered into Group III correlates poor characteristics and mechanisms for KT with low business performance results. Thus, Groups I and III bring to light the evidence of a positive growing relationship between both ensembles of descriptors, and we can conclude that when a high-tech firm does not possess optimal KT attributes or mechanisms it is certainly doomed to fail in reaching an able business performance with consequent lack of competitiveness compared to its peers, so:

if $A_C \rightarrow 0$, or if M $\rightarrow$ 0, then f (A_{NC}, A_C, (d (M) * i (M))) $\rightarrow$ 0, and IKT $\rightarrow$ 0, and BP$\rightarrow$ 0.

Likewise, a Basque high tech company has close to a 70% of probability to hold suitable attributes and mechanisms to perform KT and, thus, aspiring to get top performance status, but, according to the results obtained, less than the half of them can really be proud of reporting it. That is to say, despite that a company is running good KT dynamics, actually, it has less than a 50% of chance that KT mechanisms have been properly designed and implemented and are being duly operated.

As a result, implications of this research would be: i) Governments should implement public policies focused on: encouraging creation and development of suitable KT capabilities, and ensuring their consolidation and improvement; ii) high-tech organizations should concentrate not only on building appropriate architecture for KT dynamics, but also must check that investment is correlated to significant improvement of business performance; iii) companies delivering knowledge-intensive business services could collaborate and support firms by providing bespoke consulting and auditing services related to KT dynamics; and iv) Universities, Business Schools and Institutions fostering innovation should be involved in spreading to the business arena and even the whole society of a deeper awareness over the significance of KT, highlighting and remarking the connection between KT, successful innovation, and gain of competitiveness for the company and for the region.

Finally, main limitation of the research is the number of cases handled during the survey process, given the difficulty of access to the targeted people to capture key information, and given the resistance of some to provide data regarding the questions raised. Therefore, future research should be carried out with a wider comprehensiveness in order to endorse the principles set forth in this study and, particularly, to analyze the extent of influence of each KT determining factor on business performance.

5. CONCLUSIONS

There is compelling evidence of relationship between KT dynamics or suitability of conditions to perform KT operations, improvement of the organizational performance, and increasing of competitiveness of a high-tech company. This finding is supporting the knowledge-based view of the firm theory according to which the management of knowledge assets is appointed as the key for competitiveness. The empirical research has also contributed by bringing to light that inadequate KT dynamics entails a path towards a stage of poor business performance.

We obtained as well an unexpected result when detecting that a suitable KT dynamics does not always lead to an improvement in the competitiveness. The mere existence of positive attributes and mechanisms to carry out KT does not ensure a better business performance. The mechanisms must be properly designed, implemented and operated. It can be asserted that a Basque high-tech company fully committed to KT has actually less than 50% of probability of using properly the KT mechanisms, with the consequent lack of achievement of results and later impact on competitiveness.

Finally, we also verified that Steering Committees of Basque high-tech companies are strongly aware about the need to invest in developing individual and collective skills, and in the deployment of mechanisms for KT. However, the research proves there is a great confusion within these companies when it comes to structure and organize activities and resources associated with KT, thus putting into risk the effectiveness of the investments.

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