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# DETERMINANT FACTORS FOR SUCCESS IN SELF-SUSTAINING RESEARCH & DEVELOPMENT TECHNOLOGY CENTERS

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**ABSTRACT**

*Technological Research and Development Centers (CTID) play a crucial role along with the State and private sector in technological development policies, innovation and competitiveness. This occurs both in country and for regional development. Their scientific and technological activities are essentially oriented to applied research through technology development projects, training and specialized training of human resources as well as technological services. The aim of this study is to identify and validate the determinant factors for the success and competitiveness of self-sustainable CTID. We use focus groups and exploratory factor analysis with Varimax rotation to gather the CTID determinant factors for success and competitiveness. The inquiry covered a sample of 55 experts from research centers that constitutes 80% of the population able to respond this instrument given its expertise in these subjects. Results show that most valuable key factors in CTID are: Customer Focus, Technology Management Model, Projects Management and Business Culture.*

**JEL:** O32

**KEYWORDS:** Determinant Factors, Core Competencies, Mexican Research and Development Technology Center, Self-Sustainability, Sustainable Competitive Advantage

## INTRODUCTION

The main capabilities of the Technological Research and Development Centers (CTID) are based on organizational technologies, strategic management, continuous improvement, inter-business cooperation, technology management and human resources development, strengthening and complementing procurement processes, assimilation and diffusion of domestic or imported technologies. Optimizing and enhancing existing capabilities and operating costs and risks, guarantee their financial self-sustainability. Mexican experience shows a low historic approach between innovation and technological development (I+DT) and industry. It also shows the existence of centers of technological vocation, which have understanding, contact, and attention to industry needs. These are often oriented to make more efficient manufacturing processes in production plants (Sáenz, 2008). This allows them to be technology producers and to make a brokering role in strengthening the value chain by creating new interactions (Lizardi, Baquero & Hernández, 2008).

Skills and competencies are essential due to their role as components in structuring technological development strategies (Castellanos, 2007; Casanueva, 2001). According to Hlupic (2002), enterprise knowledge in tactical and strategic management takes the form of skills and competencies. The above demonstrates the necessity, in terms of global competitiveness where technology and innovation are key factors, that CTID focus their efforts on managing strategically their technological skills and distinctive

capabilities. Therefore, this paper identifies factors for success and competitiveness of Technological Development Research Centers operating in a self-sustaining way (CTDI-AS). This investigation provides a literature review, that describes the foundation in which unemployment is based on in the CTID and CTID-AS. The methodology lays out variables, hypothesis and process techniques of the empirical data investigation instrument. Results based on figures and tables demonstrate the theoretical bases needed to identify the key and determinant factors that feature a CTID-AS including the proposed hypothesis validation.

This document continues with a review of the literature and the state of the art about CTDI. In the methodology section we show how information was captured and processed by exploratory factor analysis and testing of a hypothesis (hypotheses contrast). In the results section the "goal of the paper", "the primary findings", "discussion and limitations" and "directions for future research" are explained.

## LITERATURE REVIEW

Merritt, (2007), in a stud about Mexican National Science and Technology Council (CONACYT), from the client's perception indicates that these Centers are distinguished for: excellent service, professionalism, cooperative behavior, and competitiveness. These results come from the quality and value of the services previously mentioned. They demand management of industry secrets and intellectual property. They also consider the possibility of obtaining unexpected ideas for new projects, tangible characteristics of the centers such as easy access and facilities quality, location and distance, the price of the services, and their public character. Mengu, (1999) points out the distinguished role of the CTID in the National System of Innovation, is due to its active participation while providing Research and Experimental Development services, providing specialized technical information, providing services, realizing research work, and training the industrial technician personnel.

We conclude that core competencies align with processes and activities of the value chain to generate a synergetic effect. This allows the development of sustainable competitive advantages based on resources and capacities in an organization (Pinto, 2007). Not all resources are strategic. This implies that not all resources generate competitive advantages. Therefore, the challenge is in determining which resocurces are strategic and create a competitive advantage.

According to Barney (1991) and Álvarez (2003), core competency characteristics include:

1. Valuable. Core competencies are the main source of development in new business and allow access to a great variety of markets. They should constitute a strategy focus in a corporative level and be directed to earn leadership in the product/service generation.

2. Rare. A core competency should be unique. When a competency becomes widely available it ceases to be a competitive advantage.

3. Prices to Imitate. A core competency should be difficult to imitate by the competition. It will only be difficult to copy if it has an absolute harmony between individuals, technology, and technical production. A rival could acquire some of the technology that comprises the core competencies, however it will be difficult and expensive to imitate the global pattern of coordination and internal learning.

4. Not Replaceable. Core competencies are a collective learning in an organization; especially the methods used to coordinate several production techniques and the integration of multiple technological flows.

Leonard (1992), Hamel and Prahalad (1990), Sáez (2000), and Álvarez (2003), provide a general treatment for the definition of core competencies. They also state that suitable definitions cannot be found that could be applied to a Public Research Center (CPI). Thus, there is no guideline to identify core competencies or what each CPI recognizes as such. We then needed to separate the concept associated with the Success Key Factors (FCE), since they form the foundation for the organization to develop their distinctive capabilities and gain competitive advantages.

To identify organization key success factors (FCE), the firm must develop distinctive capabilities and competitive advantages. An organization realizes a competitive advantage only when it has a higher level of performance than competitors in such FCE. They are the company's base elements to compete in the market. These elements should correspond to necessary distinctive capabilities in an organization to be competitive. The degree of relative mastery of the FCE determines the firm's competitive position. When companies are diversified, FCE vary the most, as these differ from one activity to another. However, some FCE may be common to any activity (Thompson & Strickland, 2002). A literature review on strategic management of organizational and technological capabilities reveals some factors considered key to the success of organizations dedicated to technological development, as seen in Table 1.

Table 1: Key Factors Identified in a CTID-AS or Pretended to Be So

| No. | Variables | Definition |
|---|---|---|
| 1 | Value proposition. | The value proposition is an integrative strategy of the organization activity, selects and prioritizes the specific elements of a product or service that are most valued by demand, making them affordable and replicable. (Osterwalder & Pigneur, 2010). |
| 2 | Organizational culture focused on innovation. | Incorporation of processes innovations or management methods in production systems of organizations to improve their productivity and cost structure, creating conditions and a work environment to make possible new products generation and the acceptance of new technologies and innovations. (Arraut, 2008). |
| 3 | Collaborative culture. | Habituating the organization to work using cross departments and interdisciplinary teams for projects execution, understanding that such mixed teams project deliverables are of greater value to the organization and the customer than the sum of individual deliverables. (Peborgh, 2013). |
| 4 | Open innovation. | Open innovation means that organizations invite experts outside the organization to participate in innovation exercises, to improve their products innovation and take into account the best market practices to complement the value of their own innovation assets, then improving return on investment. (Solleiro & Terán, 2013). |
| 5 | Projects Management System. | Methodology, software and practice of participants for project planning, management and budget control, resources allocation, collaboration, communication, quality management and documentation or systems administration, which are needed to manage the complexity involved in project deliverables generation. (Solleiro & Terán, 2013). |
| 6 | Innovation management: Technological watching. | Capture, analysis, dissemination and use of information from news and technology trends that can impact the organization's products due to increased competition for quality, price, market share, etc., becoming useful information for survival and growth of an organization. (Jakobiak, 1992). |
| 7 | Innovation Management: Technology Planning. | Process that allows alignment of the Strategic Planning with technological objectives. (Sánchez & Álvarez, 2005). |
| 8 | Innovation management: acquisition, assimilation and technological development. | Technology acquisition is a process to meet the technology needs of an organization in two ways: a) the need to improve the capacity of cleaner production, b) the need to strengthen the technological capacity of the organization, planning technology, technology development, product innovation, patents, etc. (Reisman, 2005). |
| 9 | Innovation management: Intellectual protection. | A creation of the human intellect, found in almost all knowledge areas, whether in the form of creative works such as books, films, recordings, music, art and software, or physical devices and ordinary objects such as cars, computers, medicines and plant varieties. (Singh, 2011). |
| 10 | Innovation Management: Implementation. | The process of defining the organizational structure, the provision of resources for innovation, defining policy and objectives of innovation and methods of evaluation and monitoring system itself to achieve its strategic objectives through innovation. (Corona, Garnica, & Niccolas, 2006). |
| 11 | Technology transfer (commercialization) | The transmission or delivery of information technology or a proprietary technology between it and a third party that requires it. This transfer can be done on intellectual assets such as patents, whether they are pending or granted patent. (Solleiro & Terán, 2013). |
| 12 | Technology-based companies creation ("spin-off"). | "Spin-off" expresses the idea of the creation of new businesses within other companies or existing organizations, whether public or private, acting as incubators and, in this case, are technology-based. Eventually they end up acquiring legal, technical and commercial independence. (Castillo, 2009). |
| 13 | Licensing proprietary technology. | The license is a permit, more or less, limited to technology, but that does not alter the ownership of it. You can have different objectives (use, operation, marketing), duration and full or limited application to a geographical area (in one or several countries) or to a particular use exclusivity. On the contrary, the technology transfer involves a change in ownership. (Zurano, 2008). |

| | | |
|---|---|---|
| 14 | Technological intelligence. | A tool for institution technology management that allows them to be sensible to external scientific and technological developments that may represent opportunities or threats for the company, to act promptly on the development of preventive measures such as plans and relevant technological projects. (Solleiro, 2009). |
| 15 | Performance evaluation system. | Set of procedures to collect, analyze and share information collected from and about people at work, with the intention of improving their tasks performance. Usually, it is the basic input to quantify incentives, awards, promotions, etc. (Oltra, 2008). |
| 16 | Services portfolio. | It is a document or presentation where a company details the characteristics of its commercial offer. This type of portfolio can target potential customers, business partners, suppliers, etc. (Solleiro & Terán, 2013). |
| 17 | Customer relationship management. | A model of customer relationship management is a set of guidelines and policies clearly defined and replicable compulsorily to direct the way in which the often lengthy process of sale and then the customer service is performed. The information is centralized in the organization and accessible to applicable decision makers. (Cabanelas, Cabanelas & Paniagua, 2007). |
| 18 | Human capital. | The increase in production capacity of the work achieved with improved capabilities of workers. These enhanced capabilities are acquired through training, education and experience. It refers to an individual practical knowledge and acquired skills and abilities. (Martínez & Cegarra, 2005). |
| 19 | Relational capital. | The set of all relationships, market power and cooperation established between organizations, institutions and finally materializes in the day-to-day relations between the people themselves working for these organizations. (Martínez & Cegarra, 2005). |
| 20 | Structural capital. | Knowledge the organization "hosts" in their work systems. Knowledge the organization gets explicit, systematic and internalizing and that initially may be latent in people and teams in the organization. A solid structural capital facilitates an improvement in the flow of knowledge and implies an improvement in the efficiency of the organization. (Martínez & Cegarra, 2005). |
| 21 | Physical infrastructure. | The sum of the whole set of physical and material elements, such as buildings, laboratories, workshops, vehicles and the facilities that are located in one or more specific areas. The infrastructure is not related to any primary activity, but supports it. (Porter, 1985). |
| 22 | Strategic alliances. | It is the association of two or more organizations in a new project in order to take advantage of a common market. (Ariño, 2008). |
| 23 | Explicit criteria for prioritization and resources allocation. | Methods, rules and policies that allow expression of preferences and opinions to obtain a group or authorized person decision to allocate priorities and resources. (Panitchpakdi, 2013). |
| 24 | Risk management. | Applied in setting strategies across the organization, designed to identify potential events that may affect the entity and to manage identified risks, to provide reasonable safety and integrity regarding objectives achievement. (Lefcovich, 2004). |

*Prepared from literature review. This table shows some key factors for success in organizations dedicated to technological development. They were obtained thought the literature review about the organizational and technological strategic management capabilities.*

From the review shown in Table 1, we can appreciate the concept of core competencies does not come clearly defined due to Public Research Centers (CPI) role in expressing it strategically as to not alert the competition. The same authors of this paper identified key distinctive factors that characterize the studies businesses.

## DATA AND METHODOLOGY

To validate the determinant factors for success and competitiveness of Technological Research and Development Centers in a self-sustainable way (CTID-AS), the present research was carried out through different stages (see Figure 1):

The first stage involved a documentary review of the variables identified in the literature and the actual practice of the Technological Research and Development Centers (CTID) and foreign research centers. We looked for those factors considered key to the success of organizations dedicated to technological development. We listed and conceptualized a total of 32 key factor variables.

The second stage utilized a focus group method (FG) with 10 people. Participants were asked to analyze and validate conceptual definitions and scales, the relevance level and clarity and accuracy of the formulation presented, as well as the option to propose other items or factors. The FG exercise removed and / or reformulated a group of variables, finally resulting a list of 24 variables, as showed in Table 1.

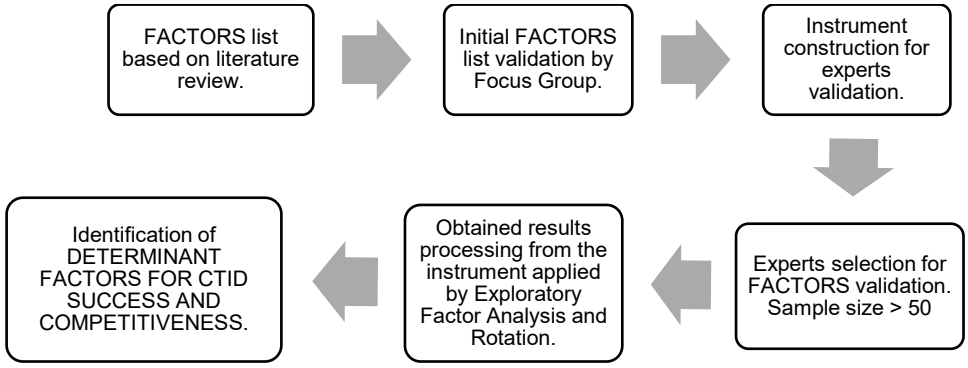
The third stage applied an instrument for key factors validation. This phase included selection of the sample, considering requirements of the statistical method used. Hair et al. (2004) indicate that one should not perform the analysis with a sample of less than 50 observations. De Winter et al. (2009) indicate that a

sample of N = 50 observations is a reasonable minimum. Consultation with 55 experts was conducted over a period of five weeks in March and April 2016, using an Internet questionnaire application, developed with 24 questions using the Likert format five answers in two successive rounds.

In the fourth stage, we reduced the number of factors. The study here is a classic case of many items that must be reduced to a small number of factors, by applying the Exploratory Factorial Analysis (AFE). AFE allows the grouping of variables into homogeneous groups. All these items can be correlated and grouped together into a single factor (Kahn, 2006), but are also relatively independent of the other items to be grouped in other factors. To assess whether the application of the AFE is possible, we calculate the measure of sampling adequacy, Kaiser-Meyer-Olkin (KMO), which consists of comparing the observed correlation coefficients with the magnitude of the partial correlation coefficients. If the calculated KMO value is below 0.6, AFE should not be applied. Another measure is the Bartlett test of sphericity, which makes a contrast of null hypothesis (H0) to assess whether the observed correlation matrix is an identity matrix. If the calculated level of significance is greater than 0.05, there is insufficient evidence to reject H0, in which ace AFE is not suitable to evaluate the data. Another test that validates whether the application of AFE is or is not possible is the value of the anti-image matrix. This test requires that values of the diagonal of the correlation anti-image matrix are high. The other needed condition is that there must be high correlations between the 24 variables.

In the fifth stage, we identify key factors for success and competitiveness of CTID-AS. The AFE method comprises of applying rotation to find factors with high correlations with a small number of variables and zero correlations in the remainder variables. It involves redistributed the factors variance. These high correlations factors are called principal components, which are then associated with the Determinants of Success Factors (Kaiser, 1958).

Figure 1: Steps in the Research Process First List, Focus Group, Corrections to the List and Expert Consultation




*Own elaboration. The research has been developed in different stages with the objective of validate the determinant factors for success and competitiveness of the CTID-AS.*

From these factors, there is the possibility of generating a Hypothesis (H1) such as: There exists a limited number of variables that identify determinant success factors for competitiveness of the CTID-AS.

## RESULTS AND DISCUSSION

As a result of this investigation, we present the AFE processing based on the instrument applied and determinant factors obtained. First, we demonstrate that all requirements to apply the AFE are met. The suitable measure of sampling adequacy (KMO) has a value of 0.848; Bartlett test value is 0.00 and the Cronbach's Alpha is 0.90. Anti-image matrix diagonal values are greater than 0.75 with an average value

of 0.86. Similarly, high correlations between the 24 variables are observed when the Pearson correlation is applied. The sample size is 55 experts (> 50), therefore we accept the sample as a valid number of surveyed experts. Participants represent 80% of the population able to respond this instrument given their expertise on these issues. Of the available methods in the strategic pack SPSS 19 this one is chosen from the main component. It explains the highest variance like as shown in Table 2.

Table 2: Variance Explained in Different Factorial Analytical Methods

| Method | Explained Variance |
|---|---|
| Main components | 69.91 (*) |
| Least unweighted squares | 64.26 |
| Least generalized squares | 63.16 |
| Alfa analysis | 63.88 |
| Imagen analysis | 62.65 |
| Maximum plausibility | 64.09 |
| Axis factoring | 64.25 |

*(*) Chosen due to the highest variance explained. Own elaboration. Of the available methods in the strategic pack SPSS 19 this one is chosen from the main component shown in this table.*

Results shown by the AFE highlight the acceptance of 18 out of 24 analyzed factors. The six factors not included have a factorial load of less than 0.6. This analysis reduces the 18 variables into four components, which explain the 69.91% of variation as shown in Table 3.

Table 3: Result of Factorial Analysis with Four Components

| Component | Sums of Square Loadings of Extraction | | | Sums of Square Loadings Rotation | | |
|---|---|---|---|---|---|---|
| | Total | % of The Variance | % Accumulated | Total | % of The Variance | % Accumulated |
| 1 | 12,966 | 54,023 | 54,023 | 5,332 | 22,218 | 22,218 |
| 2 | 1,467 | 6,112 | 60,135 | 5,128 | 21,367 | 43,584 |
| 3 | 1,256 | 5,234 | 65,369 | 3,711 | 15,463 | 59,048 |
| 4 | 1,091 | 4,546 | 69,915 | 2,608 | 10,868 | 69,915 |

*Own elaboration. This analysis can reduce the 18 variables in four components appreciated in this table.*

Varimax rotation is applied to achieve a better interpretation of results. Varimax is an orthogonal rotation method of factors that searches the best interpretation of the components or constructors. Factorial rotation aims to select the most interpretable solution. It consists of spinning the four axes of coordinates that represent the factors/components. This goes on until it gets as close as it can to the maximum variables in which (the components) are saturated. Table 4 shows the four main components (CP) that can be identified as determinant factors for success and competitiveness of the Technological and Research Development Centers (CTID) operating in a self-sustainable way. We assign names to these Determinant Factors as follows: No. 1, Client Focus; No. 2, Technological Management; No. 3, Project Administration; and No.4, Business Culture.

Table 4: Rotated Components

| Component | Client Focus 1 | Technological Management 2 | Project Management 3 | Business Culture 4 |
|---|---|---|---|---|
| **Client Relationship Standard** | 0.71 | | | |
| **Service Portfolio** | 0.60 | | | |
| **Value Proposal** | 0.87 | | | |
| ***Technological Proposition*** | | 0.66 | | |
| **Explicit criteria to assign priorities and resources** | | 0.67 | | |
| **Implantation** | | 0.64 | | |
| **Acquisition, assimilation and technological development** | | 0.60 | | |
| **Protection of the organization's patrimony.** | | 0.62 | | |
| **Administration system for projects** | | | 0.62 | |
| **Highly qualified Human Resources** | | | 0.66 | |
| **Infrastructure of I&D laboratories** | | | 0.77 | |
| **Technological intelligence** | | | 0.72 | |
| **Risk management** | | | 0.61 | |
| **Evaluation System for unemployment** | | | 0.67 | |
| **Cooperative culture** | | | | 0.60 |
| **Technological Merchandising** | | | | 0.60 |
| **Licensing of own technology** | | | | 0.71 |
| **Business creation with technological foundation (spin-off)** | | | | 0.81 |

*Own elaboration. This figure shows the four main components (CP) that can be identified as the determinant factors for success and competitiveness of the CTID-AS. We assign names to these Determinant Factors as follows: No. 1, Client Focus; No. 2, Technological Management; No. 3, Project Administration; and No.4, Business Culture.*

The assigned names have to do with the nature of the variables that make each component. They are chosen in accordance with the bibliographic analysis described in the theoretical framework. Client Focus is interpreted as a client relationship standard and a service portfolio that will find the differentiating value proposition that solves the client's need.

The component Technological Management shows the importance of having technological programming. They must have explicit criteria in assigning priorities and resources that allow their appliance such as acquisition, assimilation and technological development, and the protection of the organization's patrimony. Project Management includes a project administration system suitably structured with highly qualified human resources and lab infrastructure for research and development work. We include the technological intelligence variables, risk management, and unemployment evaluation. The Business Culture component includes all management variables, from the collaborative culture to the merchandising and technological licensing.

## CONCLUDING COMMENTS

The objective of this work was to identify and validate determining factors for the success and competitiveness of the self-sustainable CTID. Based on the results shown in previous literature, we use of a methodology involving a focus group of 10 specialists in consultation with 55 experts from research centers, which reduced the initial number of variables identified in the literature from 32 to 24. This process ratified 18 variables and provided data for the use of exploratory factor analysis (AFE). We validate the technique using Kaiser-Meyer-Olkin (KMO) sampling adequacy, Bartlett sphericity test and the anti-image matrix value with Varimax rotation. We thereby group variables into homogeneous groups and identifying the determining factors for the success and competitiveness of the CTID. We identify four determinant factors in the Technological Research and Development Centers operating in a self-sustainable way (CTID-AS). These are: 1) Client Focus; 2) Technological Management; 3) Project Administration; and 4) Business Culture. These four factors group a limited number of 18 variables that identify the determinant factors for success and competitiveness of the CTID-AS proving the hypothesis $H_1$.

The four determinant factors for CTID success and competitiveness, are associated with the fact that effective management of technology transfer involving several agents requires projects management, internal interactions management, keeping the focus on the market, networking construction, and external interactions management (Braun et al, 2000; OECD, 2003; Cotec, 2003). These are organizational capabilities of Technological Research and Development Centers (CTID), which require research, documentation and best practices. As with all research, this examination has some limitations. The primary limitation lies in the number of experts involved in the study. The number of experts selected is limited because the query criteria can only be taken from a small group of people involved in research centers. Th contribution here is useful for future work in developing a conceptual model that links the variables (key factors) and the determinant factors for success and competitiveness of the CTID-AS.

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