



TECHNOLOGY TRANSFER AND INVESTMENTS IN BRAZILIAN PUBLIC HEALTHCARE

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ABSTRACT

This study's objective is to understand the industrial and technological context involved in the offset policy and technology transfer developed in Brazilian public healthcare. Initially, the acquisition of linear accelerators for oncology treatments seemed to be a solution for the problem of long waiting lines in the Brazilian Single Health System (SUS - Sistema Único de Saúde), but the reality was different. Through the methodological procedure of a case study at a hospital renowned for its oncology treatments in the south of the country, it was possible to elucidate its ability to manage the public investment in relation to the industrial and technological context. The relevant findings show that, even with the limitations of the commercial agreement, the hospital at hand was able to, through knowledge, mitigate the difficulties of the offset policy and carry out the technology transfer with ease, due to its familiarity with the new technology.



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Through this analysis, based on the empirical context, it was possible to summarize the main benefits and setbacks that arise from the strategic and operational levels of the commercial agreement, both at its initial and final stages. This study hopes to spark new investigations on the topic in order to comprehend and intervene in different contexts and situations.

Keywords: Technology transfer; Public Healthcare; Offset Policy

1. INTRODUCTION

Emerging from public policies, government programs represent initiatives from the State apparatus in segments defined as strategic areas, such as security, health, education, economy, and agriculture, with the purpose of ensuring rights to citizenship through access to public services.

The legislation concerning public procurement is a mechanism to streamline government actions, establishing specific rules to ensure the effectiveness of the practice. Initially, in an informal context, the offset mechanism (commercial, industrial, or technological compensation) arose in Brazil in the sphere of the armed forces, which sought technologically-advanced military equipment abroad. As the counterbalance, they provided commodities and other means as payment, with the demand for transferring the technology.

Starting at the idea that the offset policy represents the initiative of disruptive technology transfer processes between different populations and acknowledging the existence of factors that influence enterprises in those contexts, the following research question is formulated: How can the industrial context facilitate the comprehension of the technology transfer processes in industrial, commercial, or technological offset measures in the scope of public healthcare?

2. TECHNOLOGY TRANSFER (TT)

Technology transfer (TT) is a simple concept but, through the lenses of an in-depth view of all of the aspects of a technology, it develops its complexity (GIBSON; SMILOR, 1991; GREEN, 1999). TT is the movement of a technology through a channel: person to person, group to group, or organization to organization, being fundamentally represented by the process of knowledge application (GIBSON; SMILOR, 1991).

To better understand TT, it is necessary to understand the definition of technology and its particularities. Technology is the representation of applied knowledge, which may be a specific component not available via a supplier but rather from a combination of knowledge



sources. It is static over time but constantly modified by every TT transaction, and in a certain way, it is unique and specific to the organization, involving a particular configuration (WAROONKUN; STEWART, 2008).

In inter-organizational relations, Aitken and Harrison (1999) found that, in countries that received foreign direct investment (FDI), usually from developed countries to developing countries, TT arises from external sources. However, in addition to accessing this technology, developing countries and productive assets enable, in the TT process, the overflow that may be employed and optimized as technological resources, know-how, marketing practices, and management skills.

Also regarding inter-organizational relations, Bozeman (2000) describes the importance of this method of acquiring technological knowledge through external partners, given that technology transfer involves the movement of know-how, technological knowledge, or technology from an organization to another. According to the author, the term has been employed to describe and analyze a surprising array of institutional interactions that involve some form of relationship with technology as the object. The sources of technology are private companies, the government, universities, and non-profit organizations.

The TT process usually involves moving a technological innovation or knowledge from a research-and-development organization to the commercialization process, often carried out by private companies and research-and-development organizations such as universities, corporate units, and government laboratories (ROGERS; TAKEGAMI; YIN, 2001). Pérez and Sánchez (2003) state that TT represents the application of information in use, involving a source of specialized technology that has technical skills and the transmission to receivers that do not have those technical skills or that cannot or will not develop their own technology.

Seen as an encompassing topic that makes use of several mechanisms to transfer technologies over political, economic, and organizational borders, the concern lies in the complex processes that feature technology innovation and commercialization to promote its absorption and imitation in both known and unknown scenarios (ANDERSON, 2005; MASKUS, REICHMAN, 2004).

Svedin and Stage (2016) discovered the existence of transaction costs in the TT process. However, the search for TT-related gains needs to be ample to justify the cost absorption. Moreover, the financial resources must be sufficient to ensure the project's viability, seeing that suitable and motivated human resources are crucial for the success of TT. Furthermore,

the process includes the purchasing and absorption of national or foreign technologies of interest to the technological capability of the country, contributing to its social and economic development (BOZEMAN, 2000; BOZEMAN; RIMES; YOUTIE, 2015).

Wisner (1994) points out that the TT process may have negative outcomes caused by several factors, including:

- Low rates of machinery use, leading to insufficient production levels;
- Unsatisfactory product quality, limiting the possibilities of exports and even compromising domestic consumption;
- Frequent activities with high levels of material deterioration, caused by the incompatibility of environmental and organizational operation conditions such as inadequate maintenance and incorrect handling;
- The causes above may begin to compromise the enterprise financially, leading to the inability to offer adequate work conditions with salaries and social benefits.

The company or the government may incur a few actions when the initial unsuccess is discovered. The search for financing to keep the enterprise active may present levels of organizational dependence on loans, which might lead to negative aspects in future negotiation possibilities.

In order to minimize the impacts caused by the TT process, the different interested parties with different institutional arrangements must articulate strategic purposes due to the several challenges imposed by the process itself. Thus, cultural differences must be overcome so that the benefits are clearly observed by the final user (WISNER, 1994; THEODORAKOPOULOS; PRECIADO; BENNET, 2012). The contribution to the development of innovative capabilities inserted in the development processes of new products and services may arise from TT, as long as it meets the level of technological development desired by the receiver (MALM, FREDRIKSSON, JOHANSEN, 2016).

3. METHODOLOGY

This study employed the participant observation method, in which the researcher proceeds directly to information gathering, interacting with the participants involved in the research object. However, the direct observation is outlined according to the dimensions and indicators defined by the literature. The involvement of the researcher with the interlocutors



present in the investigated situation represents one of the aspects of participant observation (QUIVY; CAMPEMNHOUDT, 2005).

The participant observation occurred in the organization favored by the Radiotherapy Expansion Plan in the State of Paraná, from June 2017 to October 2018. The researcher participated in the first operation of the linear accelerator equipment and followed the TT process to the selected organization.

Taking part in the flow of daily treatments, whether consultations or radiotherapy applications, the researcher noted the adaptation of the organization in terms of managing the installed capacity before the official inauguration of the linear accelerator, seeing that the organization already employed it to have a greater coverage of patients coming from the Single Health System (SUS - Sistema Único de Saúde).

The management process of the equipment required approximations between key sectors - engineering, radiotherapy, people management, and general coordination. Moreover, a document research was conducted at the hospital at hand, with the purpose of understanding how it was included in the Radiotherapy Expansion Plan, the gains attained, and the obstacles faced by the enterprise.

The participant observation allowed to establish a set of dimensions and indicators that represent the variables for the industrial context analysis, displayed in Chart 1.

TECHNOLOGICAL DIMENSION	
Set of aspects that contribute to the work process	
Indicators	
Raw material production and supply	Production and supply of raw materials for the operationalization of the linear accelerator
Types of radiotherapy	Radiotherapy classifications
Equipment supply	Location of the suppliers, available equipment, training, and maintenance
Technical organs of support/advice	Official technical organs of support and advice for the activities and actions developed

Chart 1: Dimensions of the industrial context

Source: Research data

3.1. Radiotherapy Expansion Plan of the Brazilian Ministry of Health

Instituted by the Ministry of Health's ordinance no. 931 of May 10, 2012, the Radiotherapy Expansion Plan for the SUS represents the largest investment worldwide in the acquisition of linear accelerators, aiming to expand the network of healthcare services in the radiotherapy modality and making use of offset policy mechanisms linked to the commercial contract of purchase (BRASIL, 2018).

It contemplates 80 solutions in radiotherapy, described as the creation and expansion of radiotherapy centers. The actions developed by the plan are enhancements defined as the creation and expansion of radiotherapy services through the utilization of the linear accelerator equipment at hospitals classified as Centers of High Complexity in Oncology (CACON - Centro de Alta Complexidade em Oncologia) and Assistance Units of High Complexity in Oncology (UNACON - Unidades de Assistência de Alta Complexidade em Oncologia).

4. RESULTS

The National Cancer Institute (INCA - Instituto Nacional do Câncer), organ responsible for monitoring and implementing actions through public policies directed at the prevention and control of cancer in Brazil, estimated that, during the 2016-2017 period, 600,000 new cases of cancer occurred in Brazil, with breast cancer and prostate cancer among the most common types.

In this context, a survey conducted by the INCA sought to list the most common types of cancer with primary sites according to the International Classification of Diseases and Health-Related Problems - CID (10). All types of cancer are represented by the codes C00 to C97, except for C77-C79. The types of cancer with the highest incidence in Brazil are listed below according to their primary site:

- Prostate;
- Breast;
- Cervix;
- Trachea, Bronchus, and Lungs;
- Colon and Rectum;
- Stomach;
- Oral Cavity;
- Larynx;
- Bladder;
- Esophagus;
- Ovaries;
- Hodgkin's Lymphoma;

- Non-Hodgkin's Lymphoma;
- Thyroid Gland;
- Central Nervous System;
- Leukemias;
- Uterus;
- Skin (Melanoma);
- Other Sites;
- Skin (Non-Melanoma).

Employing a specific methodology to estimate the number of new cases of cancer per Federation Unit, the INCA ascertained the types of cancer with the highest incidence in the city of Curitiba, which presented 7,510 cases per 100,000 inhabitants. According to the methodology employed.

Given the expansion of this anomaly in Brazil, linear particle accelerators may be employed in every treatment process or in the preparation for more sensitive treatments, like chemotherapy. However, the mere acquisition of these instruments does not translate into the training and infrastructure necessary for the treatment process.

4.1. Technological Dimension

Production and supply of raw materials: objects of the commercial agreement established by the Ministry of Health and the company Varian Medical Systems, the 80 linear accelerators acquired and assigned to clinical purposes are complex machines able to produce beams of ionizing rays employed in radiotherapy treatment (SOUZA, 2017). The concern in introducing the linear accelerator lies in the infrastructure to contain it.

Therefore, the basic and executive projects are based on the pact of local management, constituted by the Ministry of Health, the company Varian Medical Systems, the hospital favored by the plan, the contracting company that won the bid for the infrastructure, and the municipal and state health departments. Details like the Bunker's location, dimensions, and structural requirements for the operation of the linear accelerator are defined by the organizations included in the management pact, considering the manufacturer's recommendations, that is, the winner of the public competition (NANDI, 2004; SOUZA, 2017).

The supply of raw materials for the operation of the linear accelerator comprises electrical energy and water supply. In the first stage of the Radiotherapy Expansion Plan, the basic project establishes all of the infrastructure-related elements that need to be constructed or expanded to contain the linear accelerator. However, each hospital features particularities in its infrastructure, which requires an effort to adapt the project.

The production of energy for the linear accelerator elevates voltages, considering the current model of energy distribution in most cities, due to its electrical components. The central concern in the energy supply lies in possible overvoltages that might damage the linear accelerator, requiring adaptations in the hospital's existing substations.

During and after a radiotherapy session, the accelerator must be filled with water so that the system's cooling process is constant, avoiding any interruptions. Thus, the hospital must have a reliable water supply to avoid possible mishaps.

Types of radiotherapy: there are two kinds of radiotherapy procedures, selected according to the characteristics and location of the tumor and the treatment needs - external beam radiotherapy, also known as teletherapy, and brachytherapy. Teletherapy establishes the radiation source at a distance from the affected area, in general around 80 to 100 cm. Currently a very common type of treatment, it employs photon or electron linear accelerators and high-energy beams. One of the parameters utilized is the established radiation dose, named dosimetry, a calculation of the dose applied in the patient's treatment (INCA, 2017; SPEZZIA, 2017).

Brachytherapy directly exposes the affected region to the radioactive beams. It employs sealed radiation sources applied to the body's cavity or directly inserted into the affected region. In terms of dosimetry, brachytherapy may present a low dose rate (LDR), in which the distribution of radiation may exclude non-relevant areas, or a high dose rate (HDR), which presents a short period of exposure to radiation, usually 10 minutes, and the materials are handled via remote-controlled equipment (NANDI, 2004; SPEZZIA, 2017).

- **Equipment supply:** seeing that it is a highly specific segment, the number of linear accelerator manufacturers is reduced. However, their technological level is high, due to the technology required by this type of equipment. The manufacturers are:
- **Varian Medical Systems:** American manufacturer that highly focuses on oncology treatments. The entire manufacturing process takes place in the United States.

- **Philips Medical Systems:** Dutch manufacturer in Brazilian territory. It has a strong presence in software development employing image processing. In 1997, it acquired Elekta's radiotherapy line.
- **Elekta:** Swedish manufacturer with offices around the world. In Latin America, it is based in São Paulo, Brazil. It develops and produces equipment directed at the treatment of cancer and brain disorders.
- **Siemens Healthcare:** German manufacturer. It develops radiotherapy solutions directed at oncology treatments.
- **Accuray:** American manufacturer. It develops platforms of radiotherapy and radiosurgery for several forms of oncology anomalies.

For the Radiotherapy Expansion Plan, the Ministry of Health conducted, in 2013, an open outcry bidding process for acquiring 80 radiotherapy solutions, elaborating basic architecture projects and executive projects, supporting the inspection and supervision of the execution. According to the Official Journal of the Union of Brazil, the winning bid in the auction was the global value of R\$ 119,990,000.00 (one hundred and nineteen million, nine hundred and ninety thousand Brazilian reals), the country's largest acquisition of radiotherapy equipment.

Technical organs of support/advice: the scenario of a commercial agreement conducted through offset measures and inserted into a bidding process involves the federal authorities responsible for licensing the operation of the goods and services acquired or hired. Regarding the establishment of commercial, industrial, and technological offset measures in the civil scope, the Ministry of Treasury's Secretary of Economic Policies acts punctually with the public procurement policy, employing the State's buying power to promote sustainable economic development with the production chains.

In 2011, through the Decree no. 7.546 of August 02, 2011, the Brazilian federal government instituted the Inter-Ministry Committee of Public Procurement (CI-CP - Comissão Interministerial de Compras Públicas). This committee analyzes purchasing processes that establish margins of preference of national products, commercial, industrial, and technological offset measures, and advantageous conditions of financing access. It has the Secretary of Economic Policies as its executive secretary, which affords the committee technical and administrative support.

The members of the committee analyze the purchase proposals before the publication of the bidding notices. They are:

- Ministry of Treasury, presiding;
- Ministry of Planning, Budgeting, and Management;
- Ministry of Development, Industry, and Foreign Trade;
- Ministry of Science, Technology, Innovation, and Communication;
- Ministry of Foreign Affairs.

The bidding notices that contain any type of offset are only published after the CI-CP greenlights them, defining rules concerning the practice in federal distributions.

The licensing of operations and the inspection of constructions and facilities containing equipment that employs nuclear energy goes through the National Committee of Nuclear Energy (CNEN - Comissão Nacional de Energia Nuclear), linked to the Ministry of Science, Technology, Innovation, and Communication. The committee is responsible for establishing the national policy of nuclear energy, comprising standards, regulations, and the supervision of the production and utilization of nuclear energy in Brazil (CNEN, 2017).

Given that the object of the Radiotherapy Expansion Plan is the acquisition of linear accelerators, equipment employed with medical purposes, the authorization of the National Agency of Health Surveillance (ANVISA - Agência Nacional de Vigilância Sanitária) is required. The ANVISA is a regulatory agency that seeks to promote the population's health security through the sanitary control of the utilization and consumption of products submitted to health surveillance.

5. DISCUSSION AND ANALYSIS ABOUT THE RADIOTHERAPY EXPANSION PLAN: A CASE STUDY

Identifying the Technology Transfer in the process of introducing the radiotherapy equipment as well as the inefficiencies of the offset policy present in the Radiotherapy Expansion Plan makes it evident that the matters of populational contexts and organizational characteristics directly influence the efficiency of the enterprise at hand.

These stages represent TT due to the inter-organizational relations established by the offset policy, involving the receiving organization, the organization that holds the technology embedded in the equipment, and the mediating organizations, which establish the relation

through commerce. This idea is supported by the authors BOZEMAN, 2000; BLONHMKE, 2014; OCKWELL et al, 2010).

The organizations involved in the flow of stages did not identify as a TT process. However, within the commercial agreement, the existence of the technological offset, foreseen for the scientific and technological institutions selected by a specific call, explicitly establishes TT by focusing on the enhancement of the software made available along with the linear accelerator. The development of the insertion process depends on the articulations established in each stage. The obstacles in the first stage of the plan stand out, especially carrying out the basic and executive projects at the organizations favored. The acquisition of the equipment and its components, by itself, is a simple process.

However, developing the infrastructure to house the equipment and establishing symptoms between the organizations involved depends on several factors, such as the competence and skills of the builder organization, the spaces in the receiving structure, as well as contextual elements such as manpower, suppliers, transportation, and road structures to allow the mobility of resources necessary for the enterprise.

Analyzing the technological dimension within the industrial context, the specificity of the linear accelerator deeply limits the number of manufacturers. Because of that, the electronic auction conducted by the Ministry of Health obtained only one participant, which has institutional and strategic interests aligned with the contractual demands imposed by public procurement.

While the production of the linear accelerator takes place in the United States, the operation of the production chain is kept constant by the already-established relations. However, seeing that the commercial agreement defines counterbalances, like the installment of the factory process on Brazilian soil with a percentage of components produced by national companies within a stipulated five-year deadline, the relations need to be developed in advance to ensure and preserve the industry and the commercial agreement.

The required raw materials, the development of the Bunker, and the supply of electrical power and water are the basic elements for the operation of the linear accelerator, which are all details present in the basic and executive projects. However, developing them must be different in each of the favored organizations, seeing that structural elements may directly affect the operation and possibly lead to damaging the equipment and harming the patients.

It is evident that external radiotherapy is the most employed mode at the organization at hand, corresponding to around 70% of the radiotherapy applications. Therefore, having the necessary equipment, like the linear accelerator, in its technological park allows it to expand its capacity of patient care and reduce the waiting period of radiotherapy sessions.

The counterbalances defined by the commercial agreement will allow the manufacture of the linear accelerator on Brazilian soil, a pioneer in Latin America. However, the manufacturing process requires the establishment of the production chain, as previously mentioned.

Regarding the technical, supporting, and advisory organs at operational levels, it is important to include the participation of the federal authorities to greenlight the operations, be it the construction or the introduction of the linear accelerator, or even the licensing for continuous operations with a renovation process, according to the norm. Preparing the institutions for the initiatives is to establish relations that allow the government initiative to meet the regulatory demands and optimize the legal processing time, in the sense of making the hospital organization available for the care of SUS patients. The role of the regulatory agencies and federal authorities cannot be mischaracterized but rather praised.

Regarding the organs representing the sector, specifically cancer, the actions of the INCA and non-profit organizations highlight the concern with the disease as a public health problem. In the context of the Radiotherapy Expansion Plan, the INCA promotes several improvement courses for professionals acting in oncology with the purpose of optimizing the labor and therapeutic practices in the SUS. It also performs a role in social control, but remotely.

The patients who rely on the SUS for their treatments need information subsidies about the hospitals, palliative care, prevention methods, diagnosis, and treatment. There are numerous non-profit organizations concerned with the information support, especially the initiative of the Oncoguia Institute and its Marie Curie Operation, which informs the development of the expansion plan in hospitals with precepts of social control, that is, the control performed by organized society on the government initiative.

The inference illustrates that the local management pact, foreseen by the first stage of the plan, has not been acting consistently to comprehend the difficulties in the process of introducing the linear accelerator to the hospital environment. In turn, that shows that the pact only existed to articulate the selection, authorization, and licensing process, neglecting the

process of operationalization of the infrastructure and the required adaptations at the hospital, demonstrating the non-effectiveness of the plan and explicitly pointing to the local issues of each city, without establishing the necessary adaptations.

Identifying the central difficulties of the government initiative in the literature is the moment of understanding the implementation process of the commercial agreement at strategic and operational levels, as well as the introduction to the hospitals favored by the Radiotherapy Expansion Plan. Table 1 displays the main hurdles identified in the literature related to technology transfer and offset policy:

Table 1: Main difficulties in the utilization of offset policies

- 1. Psychological barriers of potential national investors;**
- 2. Lack of significant competition in the buyer's territory;**
- 3. Restricting approach to foreign investment;**
- 4. False sensation of technical efficiency generated by the productivity increase;**
- 5. The seller is the only responsible for reducing the transaction costs for the buyer;**
- 6. The seller is responsible for ensuring the lowest time for executing the project, consequently impacting the buyer's risks;**
- 7. High prices and less participation of the buyer in the construction stages;**
- 8. Less learning-by-doing for the buyer;**
- 9. Auxiliary competences are transferred easily, the local employees might not acquire crucial tacit knowledge;**
- 10. Impact of the technological diffusion on education, public health, environmental protection, and scientific progress.**

Source: Adapted from Matthews, 1996; Maskus; Reichman (2004); Ramady (2005). Svedin; Stage, 2016.

On the other hand, the government initiative promotes benefits that arise as the new enterprise is developed. This paper highlights the central benefits and relates them to aspects from the empirical scenario, regardless of the stage of the plan. Table 2 displays the benefits:

Table 2: Main benefits in the utilization of offset policies

- 1. Advanced technical training;**
- 2. Jobs of high aggregated value in knowledge;**
- 3. Increase of foreign investment in productive activities and services;**
- 4. Substitution of imports;**
- 5. Development of technical expertise;**
- 6. Transfer of technological knowledge via R&D and manufacturing processes;**
- 7. Enhancement in the buyer's use of raw materials;**
- 8. Investments in technologically-frail areas;**
- 9. Good perspective for the national industry in reducing costs;**
- 10. Learning process developed from the expansion of the operations' scope.**

Source: Adapted from Matthews, 1996; Maskus; Reichman (2004); Ramady (2005). Svedin; Stage, 2016.

6. FINAL CONSIDERATIONS

It is necessary to establish the existence of a TT process, seeing that the particularities of the external and internal contexts interfered and compromised the goals set by the offset policy in each context that sought to develop the introduction process. Up to now, the difficulties encountered by the government initiative take place not only at the plan's high



point, namely the introduction of the linear accelerator to hospitals, but also in concretizing the technological compensation, regarded as the formal TT, which has not happened yet. This study concludes that the greatest difficulties in the operationalization of the Radiotherapy Expansion Plan at hospitals throughout Brazil lie in the differences of each environmental, social, economic, and technological context of each region.

The situation analyzed in the case study showed, explicitly, that the success of the introduction of the linear accelerator to the hospital in Paraná occurred due to the specificities of its industrial and technological context and its status as a reference in oncology treatments to SUS patients, which enabled the expansion of this analysis to other scenarios established by the Radiotherapy Expansion Plan.

The TT processes included in the Radiotherapy Expansion Plan initially seem to be in the background, as the acquisition and the commercial relation receive greater focus. However, the effective and positive overflow of TT may contribute to the technological development of the receiving organizations, enabling them to achieve economic growth and intensify international relations centered on commercialization, TT, research and development of products, and generation of know-how. The negative overflow would be failing to concretize the TT, the equipment is not upgraded, and the commercial agreement is not optimized or actualized. Therefore, it is ideal to perform the TT first, before the equipment arrives. That way, the improvement may occur in advance and the TT is not limited as a counterbalance for the commercial agreement.

The process behaves linearly, transferring the technology embedded in the equipment acquired. The study of the offset policy directed at public health revealed the complexity of the activities that depend on inter-organizational relations, which causes structured activities and centralized decision-making to become slow and unstable procedures. The initiative is valid, but regarding the process of equipment introduction as TT and pondering about environmental contexts in terms of adaptations may represent strategic and operational gains for the institutions involved.

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