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Multi-user equipment, core-facilities and technological platforms: the evolution of organizational strategies for translational health research

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Abstract

This paper examines how institutions organize and manage the research and development (R&D) infrastructure and facilities required to stimulate innovation and convert research into

practical applications ('translational research'). We have focused our analysis on universities and biomedical institutions that have created dedicated facilities to optimize this type of activity either working in isolation or in partnership with the industrial sector. We have detected three main types of infrastructure arrangements: multi-user equipment, core-facilities and technological platforms. Although most of the institutions share a common vision and definition for the first two categories, we have identified different perceptions on the nature, role and mission of existing, self denominated 'technological platforms'. A review of these structures has led us to propose a unifying categorization and nomenclature system of these critical components of health innovation systems. Based on this conceptual framework we have analyzed the evolution of organizational R&D structures and initiatives of Fiocruz and developed a web-based system for the strategic planning, implementation and management of its network of translational research facilities located in several cities in Brazil. This approach may prove useful for organizations facing similar transitions and challenges.

Keywords: Developing countries, Health innovation, Science-Technology integration, Laboratory management, Translational research

1. Introduction

Science, technology and production are critical factors required for social and economic development which are especially interwoven in the industrialized countries' economies but weakly linked in the developing ones (SAGASTI, 2004). Using the numbers of papers and patents as proxies for scientific and technological production, Bernardes and Albuquerque (2003) classified countries into three groups: I, the least developed countries where the connections between science and technology are immature; II, the developing countries where an initial interaction between these sectors has already contributed to development; and III, the industrialized countries. This classification reflects the emergence of fast growing developing economies such as the "BRICs" (O'NEILL et al., 2005) and of the Innovative Developing Countries, IDCs, (MOREL et al., 2005), those countries with rapidly growing capabilities for undertaking health innovation. This phenomenon challenges the traditional vision of a bipolar world composed of rich countries (the "North)" and the underdeveloped world (the "South") (MOREL, 2003; REUVENY; THOMPSON, 2008) and opens up a rich research agenda to address the characteristics, organization, strategy and evolution of systems of innovation and development (LUNDVALL, 1992; NELSON, 1993; LASTRES; CASSIOLATO; ARROIO, 2005; ETZKOWITZ, 2008). Morel et al. (2005) and Mahoney et al. (2007) proposed six components, or determinants, of health innovation, which are: (1) R&D i.e. laboratory and clinical studies; (2) regulations for ensuring safety and efficacy; (3) manufacturing capabilities to meet international quality standards; (4) authoritative IP management and licensing; (5) delivery of immunization services by national public and private sectors; and (6) international procurement and trade. In addition there are two other essential elements for success - dynamic linkage and partnerships. Those countries wishing to improve their innovation capabilities must make coordinated, dynamic progress in all six determinants.

The struggle of the developing countries to link science and technology in order to stimulate innovation and achieve industrial and technological 'catch-up' has a parallel in industrialized countries: the difficulties they face to convert, through translational research, biomedical

discoveries into practical riches from which humanity can benefit (ANONYMOUS, 2008). In other words, facing the Sisyphus Challenge of the 21st Century (SAGASTI, 2004) can be as difficult as crossing the 'Valley of Death' (BUTLER, 2007, 2008). This raises the interesting possibility that similar strategies and mechanisms could be designed to serve both developing and industrialized countries in addressing their needs in expertise, infrastructure and incentives (TO THWART…, 2008). They would need to address similar hurdles and obstacles at least four levels: (i) different cultures and motivations of "star" scientists doing basic research (Mode I of knowledge production) as compared to "pasteur" scientists carrying out strategic or applied research or to experts working on technological development including clinical trials, regulation and production (Mode II of knowledge production) (STOKES, 1997; GIBBONS et al., 1994; BABA; SHICHIJO; SEDITA, 2009); (ii) differences in infrastructure, policies and governance required for basic research as compared to technological development and production (PAOLI, 2009); (iii) the changing nature of scientific enterprise in which advances require an ever-increasing number of contributors (BARABASI, 2005; GUIMERA et al., 2005); (iv)financing issues in translational health research, due to the fundamental role of the public sector in health innovation (ALBUQUERQUE; CASSIOLATO, 2002), the high costs of taking a discovery to its first clinical trials and then all the way on to drug or vaccine development and manufacturing (DI MASI; HANSEN; GRABOWSKI, 2003).

This paper addresses the organizational infrastructure needed for stimulating innovation and technological development, two critical components of translational health research. This issue has been studied from five different angles e.g.: (1) spacial and environmental factors like geographic proximity and concentration of various industrial, educational and technological assets on innovation outcomes and economic development (CASTELLS; HALL, 1994; PORTER; STERN, 2001; ROBINSON; RIP; MANGEMATIN, 2007); (2) spacial factors operating at a micro analysis level such as workspace (TOKER; GRAY, 2008); (3) organizational aspects of laboratories and publication performance (CARAYOL; MATT, 2004); (4) the role played by scientific instrumentation on the shaping and management of scientific and technological spaces (PEERBAYE, 2004; PEERBAYE; MANGEMATIN, 2005); and (5) the role of shared institutional resources on translational cancer research (PAOLI, 2009).

Our analysis focused on how leading academic institutions have organized their scientific and technological 'spaces' to cope with the challenges of translational research: how they have structured their research laboratories and facilities, how these structures operate internally and how they interact with external partners such as the industrial sector to improve the exploitation of research results and foster economic development. Three basic, increasingly complex prototypes of infrastructure/organizational arrangements could be identified: multi-user equipments, core-facilities and technological platforms. These are the building blocks of higher level arrangements such as technological agglomerations and innovation networks. Finally we used this lens to analyze the recent evolution and strategic development plans of a leading Latin American public health institution, the Oswaldo Cruz Foundation (Fiocruz, http://www.fiocruz.br), an organization closely linked to Brazil's Ministry of Health and that played a key role during "The Beginnings of Brazilian Science" (STEPAN, 1976).

The paper has five sections in addition to this introduction. The second one deals with the interaction between science and technology with a focus on health innovation and developing countries, while the third one presents the institutions included in this study, the methodology

adopted to analyse their translational research facilities and our main findings. In the fourth section the conceptual framework derived from this analysis is described. The fifth section describes the evolution of translational research at Fiocruz and how this framework shaped the present institutional strategy in health innovation and stimulated the development of a web-based system for the management of its network of technological platforms. The sixth section is the conclusion.

2. Science, technology and health innovation

2.1 Introduction

The economic impact of science and the importance of supporting academic research has been recognized since the end of World War II (BUSH, 1945; NARIN; HAMILTON; OLIVASTRO, 1997) and seems to be particularly important in the chemical and pharmaceutical industries (PAVITT, 1991) and the health sector (NELSON, 1995; GELIJNS; ROSENBERG, 1995). The reciprocal interaction and the mutual dependence between science and technology was investigated by Chaves and Moro for both the national system of innovation and the health innovation system (CHAVES; MORO, 2007). Their analysis shows that science stimulates technology and technology also influences scientific development in both class II and class III countries of the previously mentioned classification (BERNARDES; ALBUQUERQUE, 2003), although with different intensities: While in developed, class III countries 30 scientific papers generated one patent, in class II developing countries it took 120 papers to generate one (CHAVES; MORO, 2007).

2.2 What is health innovation?

Innovation dynamics in the health sector have various distinctive characteristics, especially in regard to the key importance of universities and academic research in biomedical innovations (ALBUQUERQUE; CASSIOLATO, 2002) and of service providers, patients and policy makers for health service innovation (WINDRUM; GARCÍA-GOÑI, 2008). The importance of technological and social innovation for global health was pointed out by (GARDNER; ACHARYA; YACH, 2007) and the need to incorporate innovation from the political, social, economic, and scientific realms was stressed by (JASSAL; BISHAI, 2009) in order to control diseases such as drug-resistant tuberculosis.

We have adopted two basic concepts in this paper: (i) the Health Economic-Industrial Complex (HEIC) of Gadelha that puts health questions within the context of national development and industrial policy (GADELHA, 2006) and (ii) the Global Health Innovation System (GHIS) framework of Mahoney and Morel that shows how countries at different stages of development can address the three types of health "failures" - science failures, market failures and public health failures (MAHONEY; MOREL, 2006b, 2006a). Using these lenses we focus on biomedical innovations and organizational strategies for translational health research.

2.3 Health innovation and developing country needs

The World Health Organization (WHO) and the non-governmental organization Médecins Sans Frontières (MSF) proposed the classification of diseases as Type I (WHO) or global (MSF) which occur worldwide. Type II or neglected which are more prevalent in the developing countries, and Type III or most neglected which are exclusive to the developing countries (WHO COMMISSION ON MACROECONOMICS AND HEALTH, 2001; MEDÉCINS SANS FRONTIÈRES ACCESS TO ESSENTIAL MEDICINES CAMPAIGN AND THE DRUGS FOR NEGLECTED DISEASES

WORKING GROUP, 2001). This classification represents an evolution in the term "tropical diseases", since it considers the political, economic, and social development contexts. It extends beyond a colonialistic view of geographic determinism in disease causality. It also signals that the struggle against these diseases, which particularly afflict marginalized populations, is essential for achieving the United Nations Millennium Development Goals (MDGs) (MOREL, 2006). For recent discussions on the definition and terminology of neglected tropical diseases see (LIESE; ROSENBERG; SCHRATZ, 2010; HOTEZ; PECOUL, 2010).

When the traditional view of a bipolar, "North"/"South" world prevailed, it was generally accepted that research, development and deployment of health interventions to cope with the diseases of poor countries was mainly a responsibility of the "North". This framework works for Type I / global diseases due to market forces but fails when dealing with Types II-III / neglected-most neglected diseases (TROUILLER et al., 2002; VANDERELST; SPEYBROECK, 2010). Several approaches and mechanisms have been proposed, or are in operation, to address the need for innovation and new tools to control diseases that affect poor populations (HECHT; WILSON; PALRIWALA, 2009): "Push" mechanisms, which pay for R&D up front and act directly on the different stages of the R&D process, such as, for example, grants from governments and foundations to small and medium-size companies or to multilateral organizations, such as the UNICEF/UNDP/World Bank/WHO Special Programme on Research and Training in Tropical Diseases, TDR, created in 1975 (http://www.who.int/tdr). Another of the "push" type is public-private collaboration (GODAL, 1994) which includes the nonprofit product development partnerships (PDPs), a class of public-private partnerships that focus on pharmaceutical product development for diseases of the developing world (CHATAWAY et al., 2010) (for an analysis of their investments on neglected diseases R&D see (MORAN et al., 2009) and in addition there are health innovation networks with strong participation from developing countries (MOREL et al., 2005).

There are also "pull" mechanisms, which act indirectly, offering the prospect of a financial reward or straight acquisition once the product has been developed, and thus encourage private investment in R&D such as in: multimillion-dollar prizes for a new drug for a neglected disease; advance market commitments (AMCs); Food and Drug Administration priority review vouchers (RIDLEY; GRABOWSKI; MOE, 2006; KESSELHEIM, 2009) and international financing institution that invest in the acquisition and distribution of health interventions such as the Global Fund to Fight AIDS, Tuberculosis and Malaria and GAVI, The Global Alliance for Vaccines and Immunization.

Academic research centers provide both basic research, which is the foundation of pharmaceutical and biopharmaceutical innovation, and translational medicine, which promotes the transition from basic research to applied clinical research and commercialization (KAITIN, 2010). The evolution of the medieval universities into research universities (ATKINSON; BLANPIED, 2008) in the late 19th century and recently into entrepreneurial universities (ETZKOWITZ, 2008) has made them critical components of both push and pull mechanisms and have therefore been chosen as the target of our analysis in this article.

3. Analytical work and main findings

3.1 Selection of institutions and characterization of their translational research facilities

We studied the top 200 world universities ranked in 2009 by The Times Higher Education World University, one of the most prominent world university rankings (http://www.timeshighereducation.co.uk/hybrid.asp?typeCode=438). Their translational facilities infrastructure and management characteristics were analyzed through information on the web site analyzing the following parameters: (i) nomenclature adopted; (ii) policy on cost recovery / service charges; (iii) facilities for the exclusive use of internal clients or also available to external partners; (iv) provision for training of new users or facilities exclusively run by internal, dedicated staff.

3.2 Results

Relevant information on the above parameters could be found in 164 of the 200 ranked universities (Appendix A). The preferred nomenclature is "Facility" or "Core Facility", used by 82% of the 164 institutions, but other terms are adopted by a few institutions (Figure 1). The majority of universities charge for the services provided and allow or stimulate external users, but only a third offer training to new users (Figure 2).

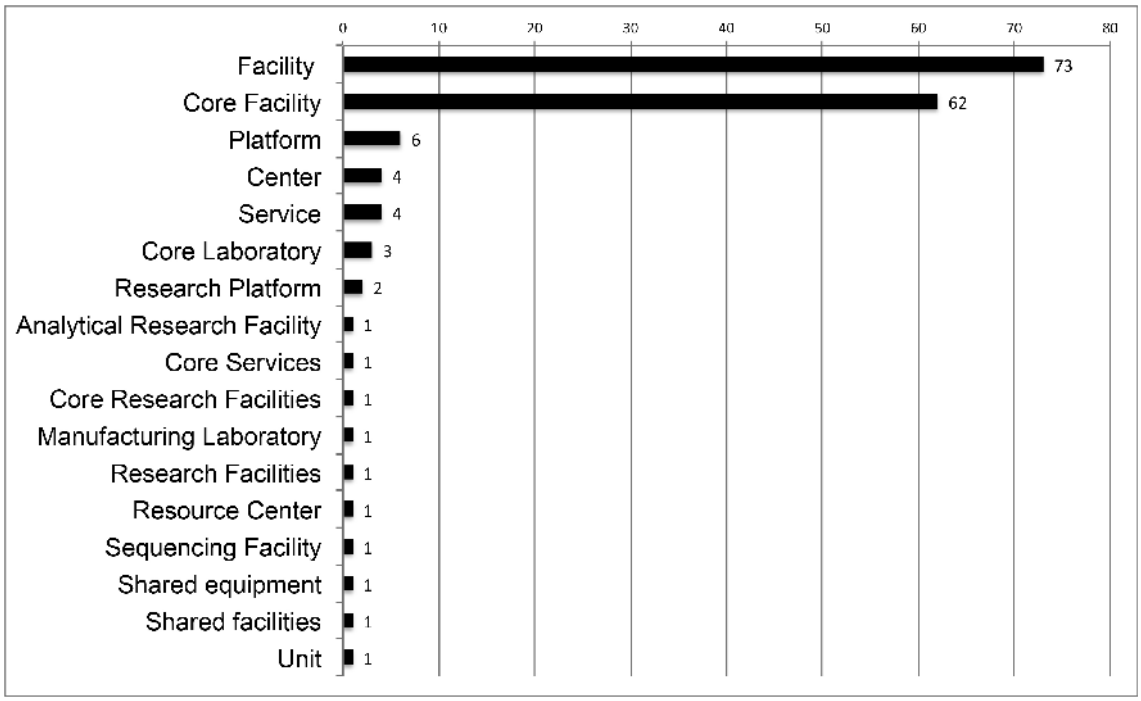

Figure 1: Nomenclature of translational research facilities adopted by leading universities. The characterization of the translational facilities of the top 200 universities ranked by The Times Higher Education World University was performed by analyzing the information provided by their web sites. Relevant information on the nomenclature adopted was collected from the 164 institutions listed in the Appendix.

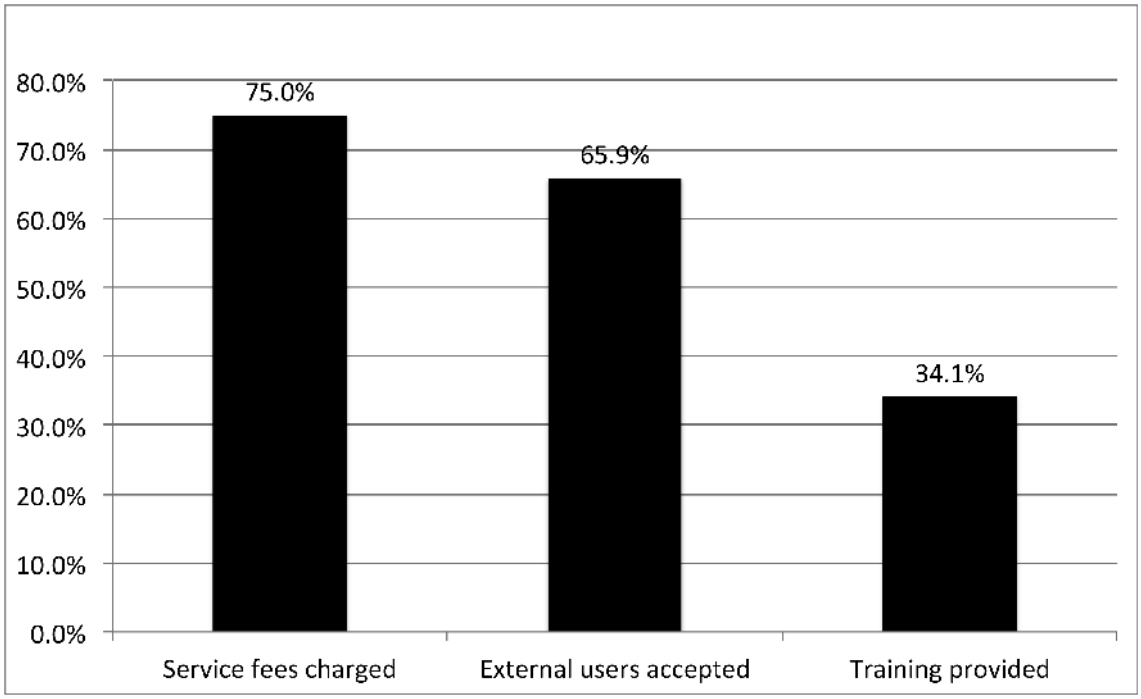

Figure 2: How universities run their translational research facilities. The characterization of the translational facilities of the top 200 universities ranked by The Times Higher Education World University was performed by analyzing the information provided by their web sites. Relevant information on the characteristics of their management system was collected from the 164 institutions listed in the Appendix.

4. Classification of translational research facilities

4.1 A conceptual and evolutionary framework for the classification of translational research facilities

Large-scale, shared research facilities are not unusual in areas such as high-energy physics and astronomy, due to the high initial investment costs and complexity of instrumentation. With the advent of modern biotechnology, scientific instrumentation in the life sciences has also become more and more resource-consuming, making sharing research facilities a priority issue (PEERBAYE; MANGEMATIN, 2005). Our analysis of the top universities described above, visits to selected institutions, a review of the literature and our own observations during the evolution of infrastructure arrangements at Fiocruz (next section) have led us to propose three basic, "evolutionary units" of instrumentation/infrastructure arrangements. The first one is "multi-user equipment" or the initial "cell" or evolutionary step which occurs when an institution decides to buy a single piece of expensive equipment to be used by two or more of their own laboratories. "Facilities" or core facilities or core service facilities (from now on Core Facilities) is the next step and it occurs when the demand for services or instrumentation use grows beyond the capacity of existing infrastructure and new trained personnel is required and hired and new, albeit simple, management rules or arrangements are put in place in order to streamline the function of the unit and to ensure quality control of results from the demanding users, internal or external. The facility is organized and operated to optimize the use of equipment and services (MAYER, 1995) and operates in a demand-driven, passive way, performing the tasks its clients or users are interested in; it requires extra funds, either from the hosting institution or collected through service charges (BUTLER; WILLIAMS, 2002). The third step is "Technological platforms" which in its simplest definition would be a "core facility

with a purpose". It is a component of, and participates in a master strategic plan, achieving clear objectives and goals. It provides services to multiple institutions, industry participation being the norm rather than an exception.

Table I: summarizes our proposal:

	Multi-user Equipment	**Core Facilities**	**Technological Platforms**
Strategy: Design, implementation and operation according to business plans or to a master strategic plan	No	No	Yes
Funding: Requires major funding from owner institution or service charges	No	Yes	Yes
Number of user or clients	Small	Medium to large	Large
Origin of user or clients	Same institution	Majority from same institution	Several institutions including industry

Our analysis shows that multi-user equipment and core facilities are natural arrangements in academic institutions as their primary goal is to provide support to all ongoing research and development activities carried out by their different laboratories or departments. The nomenclatures 'platform' and 'research platform', however, are adopted by only a minority of universities (8 out of 164; 6 institutions used 'platform' and 2 adopted 'research platform') when referring to their service facilities. We found that this term was used as a synonym of core facility by five institutions while the other three applied this label to designate infrastructure arrangements that are present in technological parks where industry has a strong presence and the priorities are business based goals or on major strategic goals of the parks themselves. The University of Barcelona (UB) represents an interesting case as it runs typical core facilities at its Scientific-Technical Services (http://www.sct.ub.es) but in 1977 also created the Barcelona Science Park, structured on technology platforms that actively participate in research and development projects in collaboration with over 60 companies based at the Park (Parc Científic Barcelona; http://www.pcb.ub.es).

5. Case study: Fiocruz

5.1 Introduction

Inaugurated on May 25, 1900 under the name of the Federal Serotherapy Institute, the Oswaldo Cruz Foundation was given the mission of fighting the great problems of public health in Brazil. The discovery of Chagas disease (*American trypanosomiasis*), its insect vector and the parasite that causes it (*Trypanosoma cruzi*) by Carlos Chagas in 1908/1909 (CHAGAS, 1909) turned Fiocruz into a think tank concerned with the Brazilian reality and experimental medicine (STEPAN, 1976).

Today the institution has over 10,000 employees and health professionals and is responsible for a range of activities which include research and development; hospital and ambulatory care services; production of vaccines, drugs, reagents, and diagnostic kits; education and training of human resources; information and communication in the area of health, science and technology; quality control of products and services, and the implementation of social programs.

Fiocruz headquarters are located at the 80 hectare Manguinhos campus in the northern part of the city of Rio de Janeiro. Spread around the three historical buildings of the old Federal Serotherapy Institute - the Moorish Pavilion, the Clock Pavilion and the Mews -, are located ten of Fiocruz's thirteen technical-scientific units and all the technical and administrative sup-port units. Other units are located around the city of Rio de Janeiro and in the cities of Belo Horizonte, Brasilia, Curitiba, Manaus, Recife and Salvador. An International Office was recently inaugurated in Maputo, Mozambique and new Units are being implemented in the States of Ceará, Mato Grosso do Sul, Piauí and Rondônia. Apart from these fixed units, Fiocruz is present all over Brazil through its support to the Brazilian Unified Health System (SUS), in its proposals on public health policy-making, its research activities, its scientific expeditions, and in the reach of its health services and products.

Figures 3 and 4 display the evolution of scientific and technological productivity of Fiocruz. For this purpose we used the "Portal de Periódicos Capes" (http://www.periodicos.capes. gov.br) to retrieve Fiocruz articles and patents from the ISI Web of Knowledge and Derwent Innovations Index, respectively. The dissociation between these two indicators is evident, the present research output of over 1,200 publications per year contrasting with the total of just 88 patents in 15 areas (Figure 5) listed in the Derwent database since its inception in 1963. This situation is a characteristic of developing countries that has already been appointed out by several authors (BERNARDES; ALBUQUERQUE, 2003; MOREL et al., 2007) leading to what (SAGASTI, 2004) has called the Sisyphus Challenge of the 21st Century.

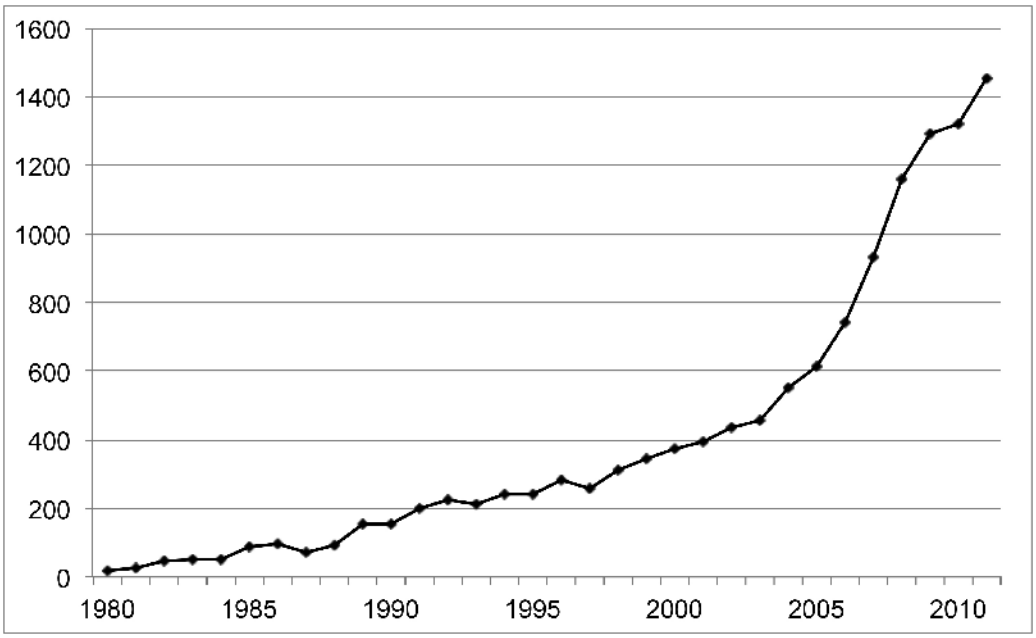

Figure 3: Evolution of Fiocruz scientific productivity from 1980-2011. Publications were retrieved from the Web of Science database on the Thomson Reuters' ISI Web of Knowledge using an advanced search mode and the following search profile based on the addresses or organizational names of Fiocruz units (e.g. "Aggeu Magalhaes" and "Deane"

retrieved the articles published by scientists working respectively at the Fiocruz Aggeu Magalhães Research Institute in Recife, and the Fiocruz Leonidas and Maria Deane Research Center in Manaus): (AD=(FIOCRUZ OR (Fundacao Oswaldo Cruz) OR (Oswaldo Cruz Foundation) OR (Fdn Oswaldo Cruz) OR INCQS OR (Inst Nacl Controle Qualidade Saude) OR (Aggeu Magalhaes) OR (Goncalo Moniz) OR (Rene Rachou) OR (Leonidas & Maria Deane) OR (Instituto Oswaldo Cruz) OR (Inst Oswaldo Cruz) OR (Oswaldo Cruz Institute) OR (Inst Pesquisas Evandro Chagas) OR (Fernandes Figueira) OR Biomanguinhos OR Bio-manguinhos OR Farmanguinhos OR Far-manguinhos) OR OG=(Deane)) AND CU=(Brazil OR Brasil).

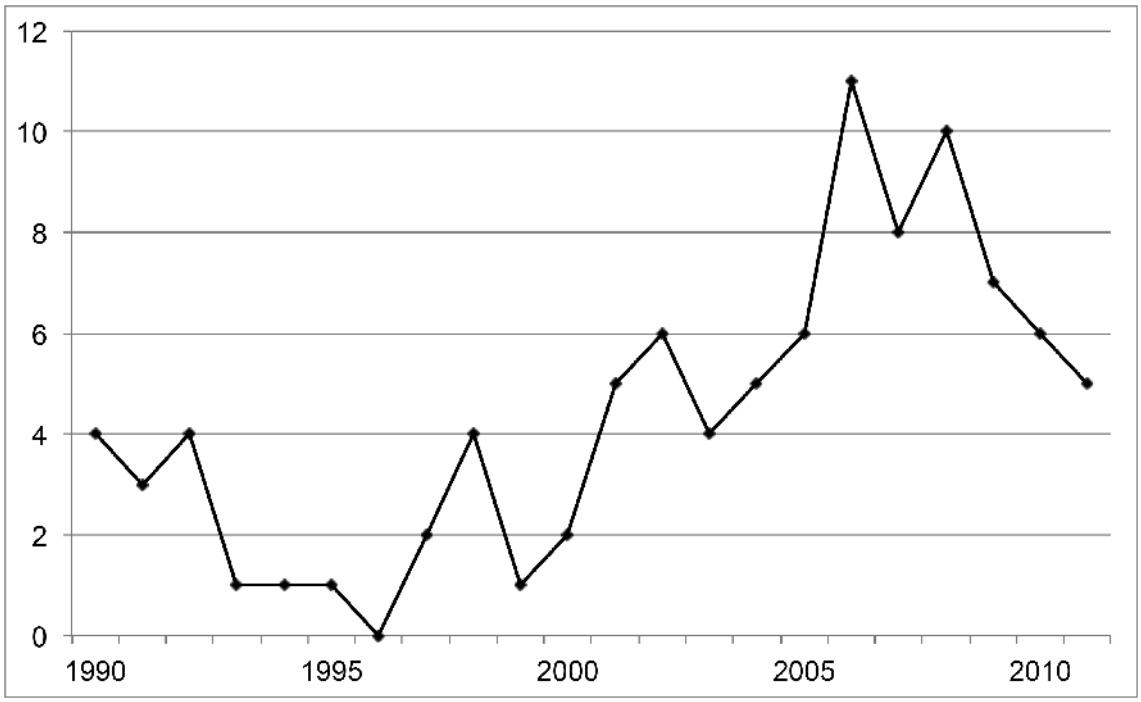

Figure 4: Evolution of Fiocruz patent applications. Fiocruz patents were retrieved from the Derwent Innovations Index on Thomson Reuters' ISI Web of Knowledge using "FIOCRUZ" as the assignee name. A total of 91 patents were retrieved using the default time span (inclusive, 1963-2011).

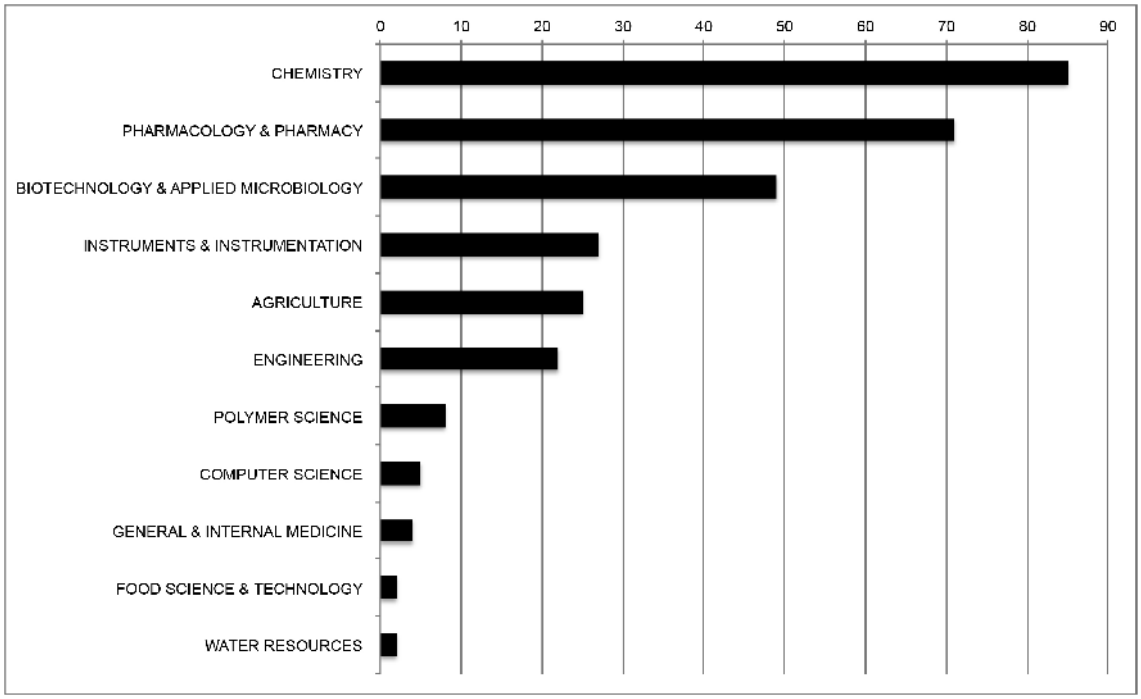

Figure 5: Subject areas covered by Fiocruz patents. The 91 patents of Fig. 4 were retrieved from the Derwent Innovations Index and processed by the site's "Analyze Results" module taking into account all subject areas covered by each patent.

5.2 Evolution of Fiocruz organizational strategies

The evolution of the R&D infrastructure of Fiocruz in the last three decades has been remarkable, allowing the institution to become one of the top performing Brazilian institutions in scientific productivity as well as production of public health goods such as vaccines, pharmaceuticals and diagnostic kits (http://www.fiocruz.br). The transition from the classical infrastructure arrangements of the 80s', based on individual research laboratories, to its present day facilities where multi-user equipments, core-facilities, technological platforms and networks are the norm, started as a slow process triggered by the acquisition of a few costly pieces of equipment such as electron microscopes (FLEISCHER, 2000) and flow cytometers (COUTINHO, 2000).

The creation of peer-reviewed, internal granting programs to strengthen Fiocruz R&D capability in the 90s' (PAPES, Programme to Support Strategic Health Research) and to stimulate innovation and technological development in the early 2000s' (PDTIS, Programme to Support Technological Development of Public Goods for Health; PDTSP, Programme to Support Technological Development for Public Health) represented a qualitative increase in investments to address growing public health demands due to emerging and re-emerging diseases such as HIV/AIDS and dengue: in the last five years PAPES has invested 7 million US dollars and PDTIS 22 million US dollars. The research laboratories funded by these programs acquired several pieces of high cost, multi-user equipment and as the need came to share them with other research groups some of these laboratories were transformed into full-blown core-facilities providing reliable services to multiple users both inside and outside the institution.

Increased pressure for more services from end users on the one hand, and for more focus, cost-effectiveness and prioritization on public health goals from the Ministry of Health and Fiocruz central management on the other, led in 2004 to the decision to integrate these core-

facilities into a structured network with the mission of providing strategic support to health innovation and the development of new vaccines, pharmaceuticals and diagnostic kits. As of today (September 2012) 47 core facilities located in 5 States (BA, MG, PE, PR, RJ) integrate the 12 technological platforms of Fiocruz (analytical methods, bio prospecting, bioassays, bioinformatics, confocal microscopy, flow cytometry, genomics, laboratory animals, monoclonal antibodies, nanotechnology and microarrays, peptide synthesis, proteomics, real-time PCR).

The need to ensure quality management, hire and train technical staff, carry on real-time management of this geographically dispersed collection of facilities, facilitate user access and interaction with industry, has led us to develop a web-based management system to address Fiocruz actions in translational health research (http://plataformas.cdts.fiocruz.br). This management system, developed by our team in partnership with NetMaker Ltd allows: (i) registered users to reserve day and time to use equipment and facilities; get information on standard procedures and methodology adopted by the different Platforms; receive online the results of the analyses of submitted samples; (ii) facility and platforms team to post results of analytical work conducted on user samples; submit regular reports on work carried out; issue occasional alerts on equipment maintenance; inform on training courses or opportunities; (iii) Managers to supervise the whole system in real time; evaluate reports and user satisfaction surveys; (iv) policy-makers to decide on investment needs and requests; discuss strategic plans, objectives and goals; (v) external partners to access general information on Fiocruz facilities and services (SOUZA, 2012).

In 2004 the Brazilian Innovation Law was approved by Congress and promulgated by President Luiz Inácio Lula da Silva. This law, possibly the first in Latin America to be national in scope and to cover a range of scientific fields (MASSARANI, 2006), provides the legal framework to allow and stimulate interactions and collaborations between the public and private sectors. This key legal instrument, compared by many to the Bayh-Dole Act in the US, was followed by a number of policies and regulations put in place to strengthen Brazil's science and innovation potential, particularly by linking up actors in the innovation system and stimulating private sector investment (BOUND, 2008): The Good Law (2005), the Programme of Accelerated Growth in Science, Technology and Innovation ("PAC da Ciência") (November 2007) and the Productive Development Policy (PDP) (May 2008). This radical change in the legal framework of the country allowed Fiocruz to launch one of its most ambitious challenges: the construction of its Center for Technological Development in Health (CDTS), a new 20,000 m^2 complex of buildings at its Manguinhos campus in Rio de Janeiro, designed to foster collaboration with the industrial sector, by providing laboratory space and management facilities, to host and support the joint development of specific health products (COSTA; MOREL; BUSS, 2005). This Center, presently under construction and scheduled to be operational in 2013 (http://www.cdtsfiocruz-english.blogspot.com), inherits several characteristics of technology agglomerations (ROBINSON; RIP; MANGEMATIN, 2007) and aims to become a Fiocruz innovation hub (YOUTIE; SHAPIRA, 2008).

Table II: summarizes the major steps taken by Fiocruz to build up and manage its facilities for translational health research.:

Arrangement	Major steps at Fiocruz
Multi-user Equipments	1970's: Electron microscopes installed at the Manguinhos campus in collaboration with the Bernhard Nocht Institute in Hamburg (FLEISCHER, 2000) and used by several researchers of the institution
Core Facilities	1980's: Fiocruz acquires and installs the first flow cytometer in Latin America to be used by its own researchers and also by collaborators or users from the Federal University of Rio de Janeiro (UFRJ) and other institutions (COUTINHO, 2000) 1990's: Fiocruz launches the Program to Support Strategic Health Research (PAPES); several laboratories acquire multi-user equipments and transform themselves into core-facilities
Technological Platforms	2000's: In order to speed up the development of vaccines, pharmaceuticals and diagnostic kits Fiocruz launches the Programme to Support Technological Development of Public Goods for Health (PDTSP) and the Program for the Technological Development of Health Products (PDTIS). Forty core facilities are supported and strengthened and are the beginning of a network of 12 technological platforms spread along several States of Brazil
Technological Agglomeration	2010's: In order to profit from Brazil's Innovation Law of 2004 and complementary policies and regulations put in place to strengthen Brazil's science and innovation potential and foster collaboration with the industrial sector (BOUND, 2008), Fiocruz launches its 20,000 m^2 Center for Technological Development in Health (CDTS) in Rio de Janeiro which will work in close collaboration with industry and the network of technological platforms of the PDTIS/PDTSP Programmes. The facilities and platforms of this technological agglomeration are managed on line by a web-based system located at the CDTS server

6 Discussion

"The world would no doubt be a nicer place if the North-South gap disappeared. But it appears unlikely to go away anytime soon." (REUVENY; THOMPSON, 2008). Sharing research facilities is commonplace in several areas of science and technology and became an important issue in the biological and biomedical sciences with the advent of modern biotechnology. As noted by (PEERBAYE; MANGEMATIN, 2005), since the development of genomics and tools for 'mass gene and protein exploration', instrumentation has become more and more resource consuming, making sharing research facilities a growing issue and a means to transfer technology.

Our analysis on how the best universities organize, share and manage their research facilities, and our study on the evolution of these arrangements during the last decades in a leading Brazilian biomedical institution, allowed us to propose a typology of increasingly complex, prototype R&D organizational structures: Multi-user equipments, core-facilities and technological platforms.

This typology, based on objective criteria (Table I), should help managers and decision-makers deal with this important component of technology transfer and translational health research, as each category needs specific requirements in terms of financing, technical expertise and

strategic management. Transforming a piece of multi-user equipment into a core-facility, for example, requires hiring and training new technical staff in quality management; moving from core-facilities to technological platforms requires profound cultural changes, as it means moving from "first-in, first-out" user attendance to deciding who, or which project, has strategic priority or rights to be served by the platforms. Incomplete or wrong perception about the nature and mission of each type of shared infrastructure arrangement can lead to the implementation of inadequate facilities, user dissatisfaction and institutional conflicts. This is particularly relevant in those sciences or institutions where shared facilities or purpose-driven technological platforms are a relatively new phenomenon and researchers have been educated in more classical ways of operation and are used to work in traditional research laboratories.

The Fiocruz case study illustrates well these issues. Brazil's new legal framework inaugurated by the 2004 Innovation Law and followed by complementary policies and regulations (BOUND, 2008) stimulated Fiocruz to discuss, define and build a network of bona-fide techno-logical platforms to support the PDTIS and PDTSP programmes, particularly in their interactions with external users including industry. This decision represented an immense management challenge: It required organizing core facilities and upgrading selected ones to technological platforms in several cities in Brazil; adopting new policies for user access; continuously monitoring operations in order to ensure quality; training staff in complex technologies, good laboratory practices (GLP guidelines), management of contracts, business plans and intellectual property. This process has required a strategically planned, profound, and still ongoing, change in the R&D and innovation culture of Fiocruz, a "path finder" organization according to the criteria of Salles-Filho and Bonacelli (2010) and therefore used to promote organizational changes and provide effective response to both internal and external challenges. The web-based system we developed and implemented to manage Fiocruz core facilities and technological platforms represented a key step and a turning point in this process, as it allowed continuous, interactive contact among all interested parties - decision-makers, managers, technical staff, clients and end users.

Partnerships between public institutions and the industrial sector are a critical component of modern biotechnology as they require innovative management and substantial investments in human resources, laboratory facilities and infrastructure. The typology proposed in this article is both a product and a driver of the long-term strategy of Fiocruz on translational health research. Transitioning from its infrastructure of the 1970s', which was based on multi-user equipments, all the way to the technological agglomeration of the 2010s' (Table II) was a long process that required critical strategic decisions and profound managerial and cultural changes. The proposed typology and this experience of a developing country institution may prove useful for organizations facing similar transitions and challenges in other countries and regions.

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