AVALIAÇÃO DE DESEMPENHO DAS ATIVIDADES DE TRANSFERÊNCIA DE TECNOLOGIA NA UNIVERSIDADE BRASILEIRA: ESTUDO DE CASO DA UNVERSIDADE FEDERAL DE MINAS GERAIS (UFMG)

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Resumo

Na maioria dos países emergentes do mundo, como é o caso do Brasil, as universidades produzem todos os anos uma quantidade significativa de invenções inovadoras e, para muitos estudos, elas podem constituir as melhores fontes de propriedade intelectual para as indústrias que, consequentemente, gerariam crescimento e desenvolvimento econômico. No entanto, para entender esse processo, torna-se necessário o questionamento sobre a colaboração entre a universidade-indústria, a transferência de tecnologia e o desempenho do escritório de transferência de tecnologia. Assim, analisando os dados disponíveis de uma das principais universidades brasileiras, o desempenho do escritório de transferência de tecnologia e inovação (TTO) é verificado usando um indicador métrico de desempenho geral específico para diagnosticar e fornecer uma visão abrangente do TTO da Universidade Federal de Minas Gerais especificamente em relação às patentes de medicamentos, bem como sua tendência em inovação tecnológica como meio de se indicar os fatores para um TTO bem-sucedido.

Palavras-chave: Propriedade intelectual; patente; desempenho; transferência de tecnologia; inovação na universidade.

PERFORMANCE EVALUATIONS OF TECHNOLOGY TRANSFER ACTIVITIES IN A BRAZILIAN RESEARCH UNIVERSITY: THE CASE STUDY OF UNVERSIDADE FEDERAL DE MINAS GERAIS (UFMG)

Abstract

In most emerging countries of the world as Brazil, Universities produce a significant amount of groundbreaking inventions every year and, to many studies, they may constitute the best sources of intellectual property to the industries which would consequently generate economic growth and development. However, to understand this process, a need to inquire into the university-Industry Collaboration, technology transfer and the technology transfer office performance, becomes necessary. Thus, analyzing the available data of one of the leading

Brazilian universities, the performance of the innovation and technology transfer office (TTO) is verified using specific overall performance metric indicator in order to diagnose and provide a comprehensive overview of the Universidade Federal de Minas Gerais' TTO on drug patents, its trend in technology innovation as means to indicating the factors for a successful TTO.

Keywords: Intellectual property; patent; performance; technology transfer; university innovation.

Abstracto

En la mayoría de los países emergentes del mundo como Brasil, las universidades producen una cantidad importante de innovaciones cada año y, para muchos estudios, pueden constituir las mejores fuentes de propiedad intelectual para las industrias que en consecuencia generarían crecimiento económico y desarrollo. Sin embargo, para comprender este proceso, es necesario consultar la colaboración entre la universidad y la industria, la transferencia de tecnología y el rendimiento de la oficina de transferencia de tecnología. Por lo tanto, al analizar los datos disponibles de una de las principales universidades brasileñas, se verifica el desempeño de la oficina de innovación y transferencia de tecnología (TTO) utilizando un indicador de métrica de desempeño general específico para diagnosticar y brindar una visión integral de la Universidade Federal de Minas Gerais 'TTO en patentes de medicamentos, su tendencia en innovación tecnológica como medio para indicar los factores para una TTO exitosa.

Palabras llave: Propiedad Intelectual; Patentar; Actuación; Transferencia Tecnológica; Innovación Universitaria.

1. Introduction

In an environment of fierce competition and trade liberalization, where innovation processes are based on the appropriation of knowledge, scientific and technological progress, the protection of Intellectual Property increasingly integrates the strategy adopted by the leading organizations, research centers and governments of countries. Research centers in Brazil are formed by both private and public organizations though uneven.

There are several public private research projects which are considered to be objective to few specific goals of private companies. Notwithstanding, the public sector has been the cornerstone of knowledge generation and impart (Chiarini & Vieira 2012). In other words, the government is responsible for the highest amount of direct investment in scientific researches either through infrastructural facilities mostly in public universities or through short and long term research sponsorship programs of the Ministry of science and technological Innovation – Ministério da Ciência, Tecnologia e Inovação (MCTI) through its research finance mechanism like Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Financiadora de Estudos e Projetos (FINEP), and indirect investment through subsidiary or tax holidays whereby the

government incentivizes private companies to invest their taxes in scientific researches and sometimes through rules of law mandating companies to invest stipulated amount of their profit in researches (Law n° 11.196, of December 21, 2005 known as the "Lei do Bem").

Thus, it is shown in this study that despite the huge amount of government investment in scientific researches, the yardstick for its investments success has, for decades until recently, been publishing of scientific articles, manuscripts etc. which makes Brazil soar – 13th position from 2010 through 2015 – amongst the highest publishers of academic scientific researches in the world (SJR 2016), however, paying a prize for the innumerous publication, which is less interest in patenting of new processes and invention, that further entangles with less applicability or transfer of the generated knowledge to production processes in the industries and extensive gap between the universities / research centers, the Industries and the government being the highest risk bearer of academic researches, and as such the famous Triple Helix Model ceases to ideally hold in this context. Otherwise, there would be an interweavement of the 3 helices, University – Industry – Governments, wherein the position of each one influences, and is influenced by, the other's position. Thus, the functions of each of the entities are altered, institutional boundaries are no longer clear and hybrid institutions emerge (Etkowitz, 2008).

Brazil, despite being one of the highest producers of basic scientific researches, it is still not one of the highest patenting countries in the world. This situation further leads to failure in its economy industries' competitiveness and transferability of technologies between the Brazilian research centers and the industries. As such, most technologies used in the process of production are either licensed by foreign companies or imported from multinational companies' home offices and adapted to the Brazilian production system, thereby causing capital flight and a slow growth in the applicability of its huge amount of basic scientific researches (Akinruli, 2016). Despite recent attempts through some public-private initiatives to revert the case, there still exist an enormous gap between the industries and the university / research centers as to choices of adopted technology and choices of production technology. There is the need to increase understanding of the real situation and performance of the Brazilian universities in relation to technology invention, transfer and management. As such, many Brazilian universities have recently embarked on fostering their own technology transfer offices – TTO, which are becoming increasingly important, given concerns regarding the universities' desire to maximize the returns to their intellectual property, especially the patents they own. The Federal University of Minas Gerais – UFMG also shares this zeal to grow in its technology innovation as it tries

to maximize through its TTO called Coordenadoria de Transferência e Inovação Tecnológica – CTIT.

Consequently, the purpose of the present study is to assess the developments and performances of scientific research, patenting (especially drug patents), and the technology transfer activities of Federal University of Minas Gerais (Universidade Federal de Minas Gerais –UFMG) through its TTO (CTIT) within the year 1990 through 2013. Finally, a future perspective of these activities of the TTO is given.

2. Theoretical Background

Intellectual property refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce. These could be protected in law by, for example, patents, copyright and trademarks, which enable people to earn recognition or financial benefit from what they invent or create. Thus, A patent is an exclusive right in the country or region in which a patent has been filed and granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. To obtain a patent, technical information about the invention must be disclosed to the public in a patent application. As such, the patent owner has the exclusive right to prevent or stop others from commercially exploiting the patented invention. By striking the right balance between the interests of innovators and the wider public interest, the intellectual property system aims to foster an environment in which creativity and innovation can flourish (WIPO 1987).

Historically, we can observe that the process of economic development of countries was founded on certain bases on their national institutions and public policies (Freeman 1987, 1988; Lundvall 1988, 1992; Nelson 1988, 1992, 1993; Pelikan 1988; Mazzucato & Perez, 2015). Developing Countries, in their quest for growth, approach the successful Developed Nations and rely on effective government support, represented by incentives to economic activity, sometimes by protectionist measures.

In Brazil, until the 30s of the 20th century, the economy was primarily based on agricultural production for export. However, changes in the international scene, due to the effects of the crisis and the end of the Second World War, led the government to introducing a policy of import substitution aimed at strengthening domestic industry (Baer 1972; Furtado 1985, 1989, Prado Jr. 1964, 1969). Subsequently, the process of industrialization in Brazil and other Developing countries was not able to fully breakaway from the past conditions of dependency (Campos, 2007). Therefore, the need for funding to support industrialization through import substitution prevented the internalization of all stages of the production chain and required technological accumulation (Blakeney, 1987). However, economies of developing countries have then also depended on technology being implicitly embedded in equipment and machinery as well as explicitly accessed via patent licensing (World Bank 2008).

Thus, the issue of access to advanced technologies, produced in developed countries economy gained relevance for the development of developing countries. The transfer of foreign technology was consolidated as a major source of innovation for the peripheral economies. However, generated situations by technical absorptive capacity of the importing institution, the existence or not of appropriate public policies, the international division of labor and the low bargaining power of developing countries in determining conditions for technology transfer, usually involve disadvantageous conditions for developing countries with regard to the commercial terms of technology imports (Figueiredo 2013; Akinruli, 2016).

In Brazil, the Federal Constitution of 1988 in its Chapter IV – Science and Technology in its Articles 218 and 219, already has an essential role of the state as a promoter of scientific and technological development, and promoting the welfare of the population focusing also on technological autonomy. The lack of government planning in the 1980s and 1990s contributed decisively to the fragility of the national economy as well as in the industrial, scientific and educational policy. Subsequently, the scientific technology delay is more than evident when compared to some countries, mainly because of budget constraints, low investment of national Gross Domestic Product – GDP and a regional imbalance of investment, added to the huge regional disparities, since 50% of these financial contributions is made by the federal government (Silva & Motta, 2008).

With the prospect of recovery of economic growth, based on improved indicators for Science, Technology and Innovation, one of the newer instruments to encourage innovation, scientific and technological research in the Brazilian productive environment is Law n° 10.973, of

December 2, 2004 known as the “Lei da Inovação Tecnológica or LIT” (Technological Innovation Law), regulated by Decree n°5.563, of October 11, 2005. This law is further shaped by a new law known as “novo marco legal da inovação” Law n° 13.243 of January 11, 2016 bringing important contributions to the national technological development as a new paradigm for the sector in Brazil.

2.1. Technological Innovation and Economic Development

The Innovation theme becomes an increasingly frequent subject in the Brazilian society. The LIT (Lei da Inovação Tecnológica) states in Article 2 paragraph IV that innovation is an “introduction of novelty or improvement in productive or social environment that results in new products, processes or services” (LEI da Inovação Tecnológica, 2004). Tidd, Bessant and Pavitt (2005) argue that innovation is an imperative process, and that this is closely related to technology, market and organization. Furthermore, it was argued that successful innovation is based on strategy, effective internal and external relationships, facilitating mechanisms of change and a supportive organizational context (Tidd *et al*., 2005).

According to Cysne, (2005) the social growth and power of nations are directly responsible for the capacity of technological innovation and the transfer and application of technology enterprises in each country (Cysne, 2005). Innovation has become a fierce competition between companies and countries, and handling technological knowledge leads to economic and political domination, in the view of Staub (2001). And, in that scope of intense scientific and technological competition, Technological Innovation Centers are immersed.

Giovanni Dosi (1982), Technological Paradigms in their work and Technological Trajectories, published in the journal Research Policy, bringing in the question, for example, pillars of conventional economic thought, as the assumption of the “price mechanism” as the main instrument of competition between firms; and the premise of the market “equilibrium tendency”.

In an attempt to understand the role of technology and technological change in the economic development process, the aforementioned author investigated two major explanations for technical progress used as premises of neoclassical current. The first, known as “demand-pull

theory", put market forces as the main mechanism responsible and supportive of technological change. Therefore, it would be the recognition of the needs of the society by the productive sector, would boost this sector in order to make efforts to meet those needs. However, according to the author, this theory would not have succeeded in producing sufficient evidence to conclude that the needs signaled by the market would be the driving force of innovative activity.

Dosi questioned a number of characteristics of the demand-pull approach, among them, a reactive concept, passive and mechanical, technological change in the face of market conditions, the inability of the theory to define why and when certain technological developments happen instead of others, and the fact that the theory neglects of the inventive capacity changes occurring over time, which showed no relationship in changes in market conditions (Dosi, 1982).

The second neoclassical theory criticized by Dosi and driving force of technological innovation, was known as "technology push theory". This current delegated to increasingly rapid changes in scientific knowledge, and the consequent search for practical applications for this knowledge, the role of driving force of innovation. However, on this approach, the author drew attention to some aspects: the growing complexity of the innovation process, and the role of science and R & D in this process, and the relative autonomy of the firm, and the inherent uncertainty of innovative activity, one needs to "bet" to a hypothesis, which in turn has a limited and known choices, and set of results. Dosi further defines "technological paradigm" as "model" and a "pattern" of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies.

Based on the concepts associated with the Schumpeter theory, it is possible to observe characteristics of the evolution of technology and its implications for economic development. A given technological paradigm establishes a possible notion of progress from its technical and economic aspects. Therefore, the technological trajectory to be covered in search of new solutions to issues associated with that paradigm. And the maintenance or disruption of these paradigms is often related to economic cycle characteristics of the development process (Freeman & Perez, 1988; Nelson & Winter, 1982).

2.2. The Brazilian Structure of Science, Technology and Innovation

Despite the lacks of specific regulations and detailing, Matias-Pereira and Kruglianskas (2005) defines the Brazilian technological innovation law (Lei da Inovação Tecnológica – LIT) as an important institutional tool to leverage and support the Brazilian industrial technology policy. Other documents such as the White Paper on Science, Technology and Innovation Ministry of Science and Technology (2002) had already pointed out the implementation of an effective National System of Science, Technology and Innovation (STI) in the country as one of its strategic directives.

The Brazilian structure of Science, Technology and Innovation is much younger compared to other developed countries. Matias-Pereira and Kruglianskas (2005) argue that countries should move consistently in scientific and technological knowledge. In the Brazilian case, the Innovation theme is also somehow an issue in the margins of the civil society. The responsible for the formulation and implementation of the National Policy on STI is the Ministry of Science, Technology and Innovation (Ministério da Ciência, Tecnologia e Inovação – MCTI). Created by Decree nº 91.146 of March 15, 1985, later consolidated in Chapter IV of the Constitution of 1988 and attends a longstanding desire of the Brazilian Academy of having a public agency with direct administration like the central stakeholder structure of the national science and technology. In the Brazilian context, there is a National Council for Science and Technology (Conselho Nacional de Ciência e Tecnologia), created by Law n° 9.257 of 09 January 1996, formed by representatives of the Government, Industry and Academy, whose skills consulted on industrial policies.

Staub (2001) states that one of the strategic challenges for Brazil is rebuilding the productive capacity and building more capacity to innovate in technology-intensive sectors. New legislation for the regulation of Intellectual Property, along with government incentive programs for University Partnership – Company are to Santos (2009), a new scenario in the national context of promoting technological innovation. Whereas in Rapini and Righi (2007) there is the firm academic belief that University – Industry interaction is specific to each country and is always dependent on national science and technology infrastructure.

2.3. Technology Transfer

Technological advancement is frequently linked to economic progress and social benefits. Advancing technologies also forms much of the business of university scientific research.

Frequently, however, university research is not smoothly, or even successfully, transferred to industry (Markham *et al.*, 1999). Wittamore *et al.* (1998) adopted a working definition of technology transfer as: the transfer of new knowledge, products or processes from one organization to another for business benefit. Other authors emphasize the importance of the ‘‘techniques and skills to operate’’ the technology as well as the ‘‘managerial skills’’ required to exploit it (Czinkota *et al*., 2002). While Tidd *et al.* (2001) affirm that the need for ‘‘user education’’ by the supplier of the technology and ‘‘transfer support’’ are also important concerns.

Technology transfer is not a new business phenomenon. Though, the emerging considerable literatures on technology transfer over the years agree that defining technology transfer is difficult due to the complexity of the technology transfer process (Robinson, 1991). The definitions depend on how the user defines technology and in what context (Chen, 1996; Bozeman, 2000). The term technology transfer can be defined as the process of movement of technology from one entity to another (Souder *et al*., 1990; Ramanathan, 1994). The transfer may be said to be successful if the receiving entity, the transferee, can effectively utilize the technology transferred and eventually assimilate it (Ramanathan, 1994). The movement may involve physical assets, know-how, and technical knowledge (Bozeman, 2000).

Technology transfer has also been used to refer to movements of technology from the laboratory to industry, developed to developing countries, or from one application to another domain (Philips, 2002). In a very restrictive sense, where technology is considered as information, technology transfer is sometimes defined as the application of information into use (Gibson & Rogers, 1994). In this sense, economists such as Arrow (1969) and Dosi (1988) have analyzed technology transfer on the basis of the properties of generic knowledge, focusing particularly on variables that relate to product design. Mittleman and Pasha (1997) have attempted a broader definition stating that technology transfer is the movement of knowledge, skill, organization, values and capital from the point of generation to the site of adaptation and application. Thus, technology transfer is one of the key stimulating gears of scientific knowledge generation and exploration as well as intellectual property rights protection with the capacity of establishing economic growth and development when properly applied and well managed.

3. Methodology

The methodology employed, disclosed and described in detail in this study reflects a combination of various performed tasks in the research and an assembly of materials used for this purpose. The goal of this scientific activity is comprehensively summarized in an attempt to obtain a better understanding of the interdependently involved fields. Moreover, we attempt to bridges the gap between the observation of reality and scientific theory, thereby searching for their tangential points. To reach our result, all Intellectual Property (IP) activities and IP contracts of UFMG were studied singly *in loco* and semi-structured interviews which guides understanding of the peculiarity of each analyzed technology and its related contract (s) thereby keeping our chance of error to its barest minimum. Furthermore, the retrieved data was narrowed down to focusing more on the ones related to drug patents which has the Brazilian IP classification A61K, and later compared to data from other sources including INPI, WIPO, and EPO, which were collected from their respective available database on the internet.

Data Collection Methods: The method used in data collation of our case study can be characterized as: quantitative conducted through comparative analyzes of data collected from various sources including both Brazilian and international database. By the nature of this research, we opted for a case study of phenomenological nature, with the creation of data based on theoretical propositions, as suggested by Eisenhardt (1989) and Barratt *et al* (2011).

Data Sources, Validity and Reliability: As for the quality of the study, calculated measures were taken on the construct validity and reliability suggested by Yin (1994). In order to avoid errors related to the construct validity, the research is backed up by a wide range of related literature as well as using multiple sources of evidence to buttress the emphasis. As for reliability, some sort of nationally and internationally reliable institutions' databases served as sources of the analyzed primary and secondary data. These include information from the database of Universidade de Minas Gerais – CTIT, the Brazilian Instituto Nacional de Propriedade Industrial – INPI's SINPI, the European Patent Office – EPO's Espacenet, and the World Intellectual Property Organization – WIPO's Patent Scope.

Based on earlier studies of researchers like Tseng & Raudensky (2014); Trune, Goslin (1998); Rogers, Ying, Joern (2000); Thursby, Thursby (2003); Litan, Mitchell, Reedy (2007); Roessner, Bond, Okubo, Planting (2009); Xu, Parry, Song (2011) and those by Anderson, Daim, Lavoie (2007), Abrams, Leung, Stevens, (2009), York, Ahn (2012), Foltz, Barham, Kim (2000), O'Shea, Allen, Chevalier, Roche (2005), West (2012) and Kurman (2011), the performance measure for a TTO can be quantified by the following metrics: a) TTO revenue, b) number of

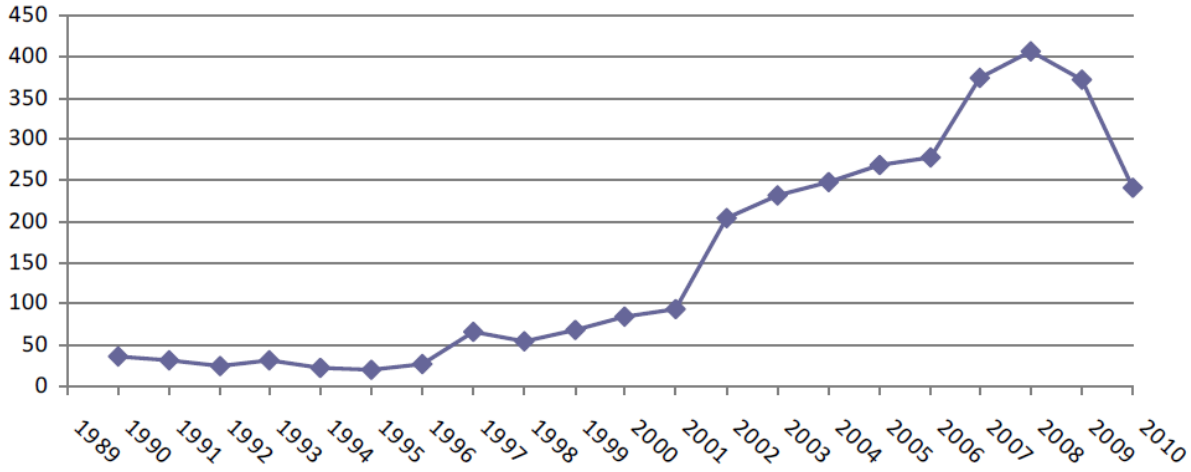
invention disclosures, c) number of patent applications, d) number of patents granted, e) number of licenses signed, f) number of start-ups formed, g) research expenditure of university scientists, h) expenditure of patenting activities, i) operation expenditure, j) number of new commercial products, k) employment and productivity growth of startup partners, l) changes in stock prices of industrial partners, etc. However, in the present study, only few of these metrics are adopted for the quantitative evaluation of TTO performance for the research universities – UFMG due to the restricted level of access to some specific data. Therefore, it should be noted that TTOs in emerging countries like Brazil may be reluctant or, according to the organizational customs, not permit total access to all necessary data as it may have been in the case of the United State of America where the scenarios have drastically changed after the passage of the Bayh-Dole Act by United States Congress in 1980.

4. Results and Discussion

UFMG's Position Amongst the Six Leading University Patent depositors in Brazil

Foremost, we highlight UFMG's position amongst the six leading university patent depositors in Brazil. The evolution of seeking patent protection by Brazilian higher education institutions, called universities in the period 1990-2010 (Luciana, 2013) can be seen in Graph 1, below:

Graph 1 – Brazilian University Patent Deposit Trend (1990-2010).



Source: INPI's database.

During this period of study, a total of 3,189 filings of patents were accomplished by 103 depositors from national institutions in the country. In order to enable a more detailed discussion and view the dispersion of deposits between universities a ranking was built, included in Table 1 below, which simply contains the universities with more than sixty (60) patent applications, which are twelve (12), responsible for the total of 2,486 applications found.

Table 1 – Brazilian University Patent Deposit Ranking (1990-2010)

Ranking	Institution	Acronyms	State	N° of Doc.	(%)
1st	Universidade Estadual de Campinas	UNICAMP	SP	651	22,16
2nd	Universidade de São Paulo	USP	SP	550	18,69
3rd	Universidade Federal de Minas Gerais	UFMG	MG	344	11,71
4th	Universidade Federal do Rio de Janeiro	UFRJ	RJ	274	9,33
5th	Universidade Federal do Rio Grande do Sul	UFRGS	RS	128	4,32
6th	Universidade Federal do Paraná	UFPR	PR	102	3,47
7th	Universidade Estadual Paulista Julio de Mesquita Filho	UNESP	SP	98	3,34
8th	Universidade Federal de Santa Catarina	UFSC	SC	75	2,55
9th	Universidade Federal de Viçosa	UFV	MG	70	2,38
10th	Universidade Federal de São Carlos	UFSCAR	SP	68	2,31
11th	Universidade Federal de Pernambuco	UFPE	PE	63	2,14
12th	Universidade de Brasília	UNB	DF	63	2,14

Source: INPI's database.

From Table 1, it can be seen that the State University of Campinas (UNICAMP) ranks first with a slight difference to the second place, the University of São Paulo (USP). The Federal University of Minas Gerais (UFMG), which appears in the third position, appears to have a slight advantage over fourth place, the Federal University of Rio de Janeiro (UFRJ). It is also observed that all twelve universities that appear in this group are public, highlighting the importance of government policies and guidelines for the establishment of the current standard of teaching and research as well adequate budget to maintain the quality of the implemented research and operating apparatus to perform the administrative and technical activities for the protection of Intellectual Property assets. It is observed that UFMG's patented invention is more concentrated on the subclass A61K – "preparations for medical purposes", with 70 occurrences and subclass C07K – "Peptides", with 30 in C12N – "Microorganisms or enzymes" with 19, C07C – "acyclic or carbocyclic compounds", with 15 and G01N – "Research and

analysis of materials by their physical or chemical properties" with 14. It is however notable that up to the year 2010, UFMG was the second highest depositor of drug patent with the IP classification A61K, which is of utmost relevance to our case study.

The Federal University of Minas Gerais – Universidade Federal de Minas Gerais (UFMG)

According to the MEC, UFMG is one of the universities that receive the most funding from the federal government, since it is one of those that most offers courses and programs for teaching, researches and extension (MEC 2014). UFMG is also one of the largest centers of innovation in Brazil. According to the National Institute of Industrial Property (INPI) in 2010, UFMG was the Brazilian institution that most deposited patents.

Current Data of UFMG's Production as at April, 2016

Table 2 – UFMG's Production Indicators (2016)

Number of professor at UFMG	2.940
Number of professors with lattes	2.902 (98,71%)
Registered number of units (faculties)	23
Number of patents	762
Número de laboratórios	573

Sources: Elaborated by the authors

We hereby highlight that as at the year 2016, the UMFG's department with the highest number of patent deposit (194) is the Biology Science Institute (Instituto de Ciências Biológicas – ICB) despite it being with the fourth highest (8%) amount of professors and second highest amount of laboratories (119), followed by the Engineering school which is the second highest depositor of patents despite being with third highest amount of professors (10,7%) and has 173 laboratories. It is also notable that the Faculty of Medicine (Faculdade de Medicina) is with the highest amount of professors (13,7%) though has lesser amount of laboratories (29) compared to others and deposited 15 patents. The faculty of Pharmacy has 2,5 % of the professor to its 33 laboratories and produced 72 patents deposit. These show that many contingencies determine what is researched, who researches, and facilities as well as resources for technology development. Subsequently, we shall see the evolution of patents in UFMG and their transfer focusing more on the drug patents.

Coordenadoria de Transferência e Inovação Tecnológica (CTIT – UFMG)

At the Federal University of Minas Gerais (Universidade Federal de Minas Gerais – UFMG), the management of intellectual property and innovation activities is exercised by the UFMG Center for Technological Innovation called Coordenadoria de Transferência e Inovação Tecnológica – CTIT, which is subordinate to the Dean of Researches (Pró-Reitoria de Pesquisa), according to its internal regulations, observing the provisions of Art. 16 of law 10.973/04, art.17 of Decree 5.563/2005 and resolution N° 08/98 with the University Council's approval.

As such, CTIT which was founded in 1997 ordained with the responsibility of organizing and managing all UFMG's intellectual property and related innovation. It is also noteworthy to include that all registered patent deposited by UFMG's members of staff within 1992 and 1997 using the university's equipment and resources before the existence of CTIT were all in the researchers' names as patentees as guided most often by the INPI, but later regulated by CTIT and the ownership transferred to UFMG while they remain the inventors.

CTIT is permitted to celebrate UFMG's technology transfer licensing agreements for granting the right of use or exploitation of creation, wherein UFMG stands as the proprietor or co-proprietor of the creation, either through exclusive proprietary and non- exclusive proprietary. Decision on exclusivity of transfer or licensing is overseen by the Reitoria de Pesquisa (the Dean of Research), who hears CTIT, for the purposes mentioned in its regulatory, and should be preceded by the publication of a notice, which must comply with the provisions of paragraph 3, art. 6 of Law 10.973/2004 and art. 7 of Decree 5.563/2005.

Results of Analyses of the activity data of UFMG and CTIT (1990 and 2013)

This aspect shows the result of the exploration of available information of all drug patent of UFMG deposited with the National Institute of Industrial Property – INPI between 1996 and 2013 being the available data in the INPI's database, as well as the academic evolution in all units of UFMG which has available data from 1990 through the first month of 2014. These shall be compared with other relevant data to this study from CTIT – UFMG as shown below. It is noteworthy, based on the verified database of the Brazilian INPI, that there are no records of Drug Patents by UFMG before the year 1996, while there is no published IPC for all patents in the year 2013 by the responsible organ in Brazil - INPI which makes a part of this analysis, i.e. Deposited Medicament / Drug Technology from UFMG, limited to the year 2012, therefore we shall not consider the year 2013 in the analysis of Drug Patent Deposit (IPC=A61).

Table 3 – Performance data of UFMG and CTIT (Jan./1990 – Mar./2014)

Year	Total Scientific Production	Total Annual Patent Deposit	Drug Patent Deposit (IPC=A61)	Total n° of Contracts	Transfer / Licensing Contracts	Transferred / Licensed Drug Patents (IPC=A61)	Other Contracts
1990	1363	0	0	0	0	0	0
1991	1656	0	0	0	0	0	0
1992	2153	1	0	0	0	0	0
1993	2407	0	0	0	0	0	0
1994	3133	0	0	0	0	0	0
1995	3792	2	1	0	0	0	0
1996	4493	10	3	0	0	0	0
1997	5392	27	16	0	0	0	0
1998	5990	1	0	0	0	0	0
1999	7078	3	1	0	0	0	0
2000	7885	10	3	0	0	0	0
2001	8207	20	10	0	0	0	0
2002	9231	27	12	0	0	0	0
2003	9696	22	7	6	2	2	4
2004	10047	27	12	4	4	0	0
2005	11608	21	8	7	3	2	4
2006	11571	32	18	4	0	0	4
2007	12563	42	22	10	0	0	10
2008	13120	45	23	19	3	2	16
2009	13204	46	16	22	6	0	16
2010	12803	64	20	12	4	0	8
2011	13488	75	22	23	7	1	16
2012	13491	80	10	44	8	1	37
2013	10316	77	0	44	13	2	31
2014	492	NA	NA	NA	NA	NA	NA
2015	NA	NA	NA	NA	NA	NA	NA
TOTAL	**19.5179**	**632**	**204**	**195**	**49**	**10**	**146**

Source: Elaborated by the authors

Year: A range of 23 years from 1990 – 2013;

Total Scientific Production: Total annual amount of scientific publication;

Total Annual Patent Deposit: Total annual amount of deposited patents with INPI;

Drug Patent Deposit (IPC=A61): Total annual amount of deposited drug patents with INPI

Total nº of Contracts: Total annual amount of UFMG's contracts exercised by CTIT

Transfer / Licensing Contracts: Total annual unit of contracts involving licensing and technology transfer.

Transferred / Licensed Drug Patents (IPC=A61): Total annual amounts of patents involved in licensing and transfer contracts.

Other Contracts: All other existing contracts between CTIT and other organizations.

NA: Data not available.

In order to avoid inconsistency due to unavailability of complete data, we have limited our use of data collection from the database to the year 2013.

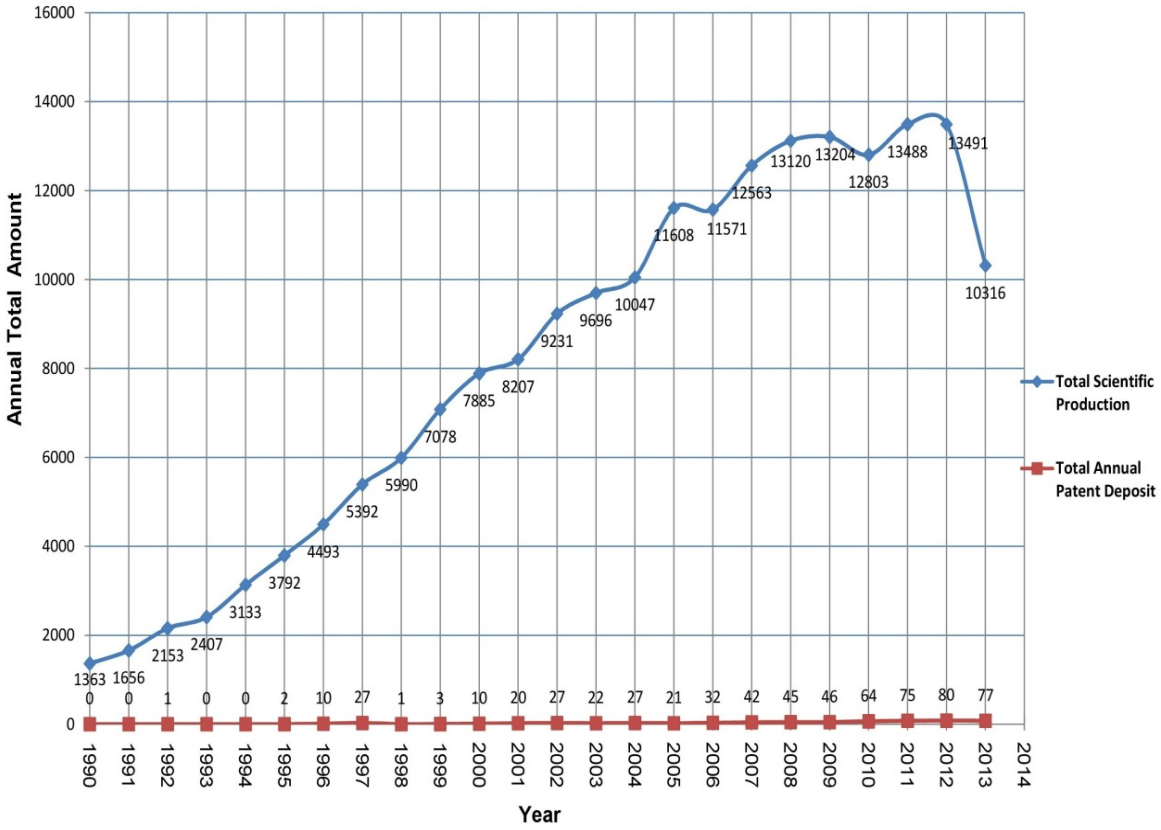
Notably, when the data obtained from both database of INPI and CTIT were compared; it was observed that there were some differences in the recorded number of patents by year as shown below. Nevertheless, we have chosen to use the highest registered number between both sources of our variables as demonstrated above in table 11 since it is not possible to affirm that one of both is the most correct.

In order to better understand the dynamics and functionality of UFMG and its intellectual property and innovation management sector, CTIT, we hereby explore the available records of its annual patent activities and scientific knowledge production since the year 1990 till date, i.e. from January 1990 to December 2013 as shown above in table 3.

Furthermore**, Drug Patents** is defined as patents with the IPC classification A61, while **Other Contracts** as in Table 3 are all the contracts involving UFMG's technological innovation exercises including partnership with other institutions except Licensing and transfer contracts. In other words, Total Contracts less Transfer/Licensing Contracts equals Other contracts.

As shown on table 3 above, we shall consider some variable that are extracted from primary sources like CTIT's database which include employees' records, transaction documents, Contracts, files, etc., as well as the INPI's database. Collated data from INPI's database are available to the generality of the public on the website's Patent Search Engine (Sinpi). Based on this, a discussion is presented below using the variables:

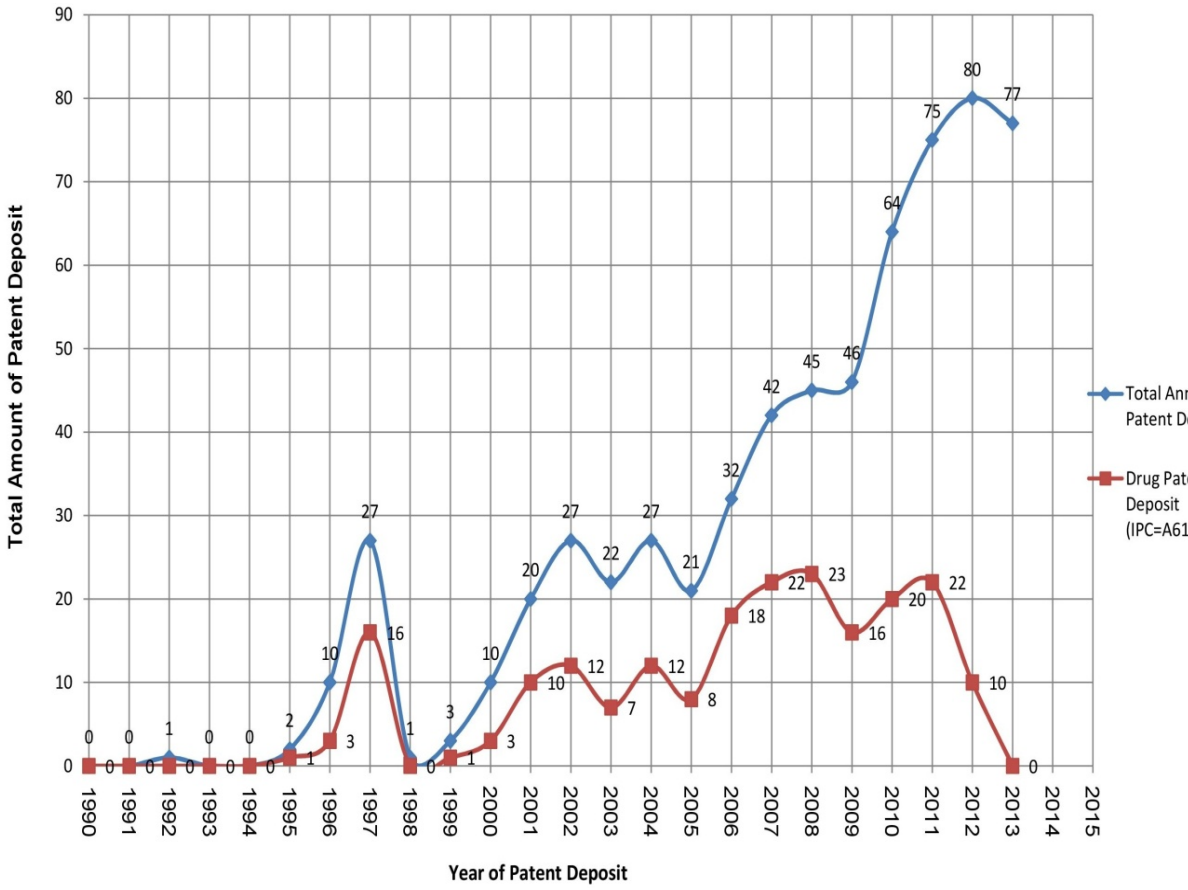
Graph 2 – UFMG: Total Annual Output of Scientific Production Compared to Patent Deposit (1990-2013).



Source: Elaborated by the authors

On graph 2, we show a comparison of two variables which could be a way of quantifying the level of disparity between the overall academic production and the possible economic return derived from it. Here we compare the annual growth in scientific publication from academic researches to the annual growth in patenting in UFMG. Therefore, it is observed that the scientific publications rise annually in an increasing rate to tens of thousands along the years with its current maximum being 13,491 in 2012, while patenting crawls in tens with its current maximum being 80 according to findings of this present research. This depicts the huge level of discrepancy between publishing and patent application.

Graph 3 – UFMG: Total Annual Patent Deposit Compared to Annual Medical Patents (1990-2013).

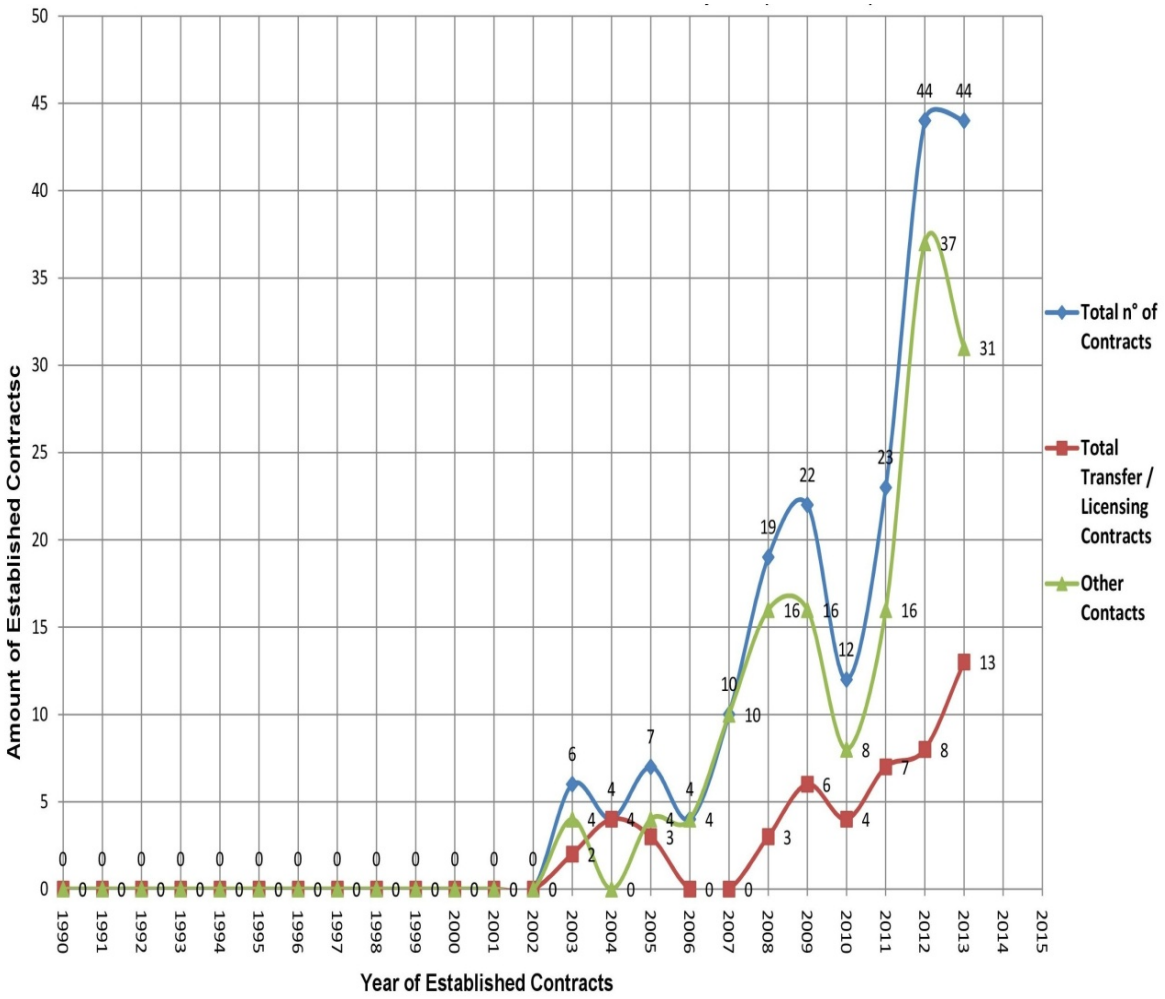


Source: Elaborated by the authors

Graph 3 shows the annual growth of total deposited Patents compared to total deposited drug patents along the last twenty-three years. It is observed that before the year 1995, UFMG owned only one patent deposited in 1992, which implies that the patenting culture is still almost at its cradle today considering the required period for the granting of a patent. Furthermore, findings of this research depict herein that though the first 10 years (first decade – 1992 through 2001) of patenting, the annual growth of total patents attained the maximum of 27 patents amongst which drug patents (IPC A61) were 16 as recorded in 1997. The second decade (2002 through 2011) portrays annual growth of patents attaining over a double growth of 64 patents as recorded in the year 2011. In the third decade (2012 – till date), the growth rate of patenting is maintained, therefore reaching 75 in 2012 and the maximum of 80 in 2013 respectively. On the other hand, Annual deposit of drug patents experienced a downward slope to its barest minimum being zero (0) IPC A61 patent in 1998 (still in the first decade of UFMG's patenting). However, subsequent years seem to be redeeming as annual drug patents increases to attain its maximum of 23 in the year 2008 of the second decade of patenting (2002 through 2011). The years 2012 and 2013 demonstrate a recent decline as the annual deposit of drug patents are at

22 and 10 respectively. Nevertheless, the record of 10 in 2013 is to some extend arguable that there may be some recent patent deposit which are not yet given IPC classification or not made available by INPI, since the finding of this research detects that publishing of IPC takes a long process and the INPI often demonstrate backlogs in some of its processes.

Graph 4 – The Trend of UFMG's Established Patent Based Contracts by CTIT (1990-2013).

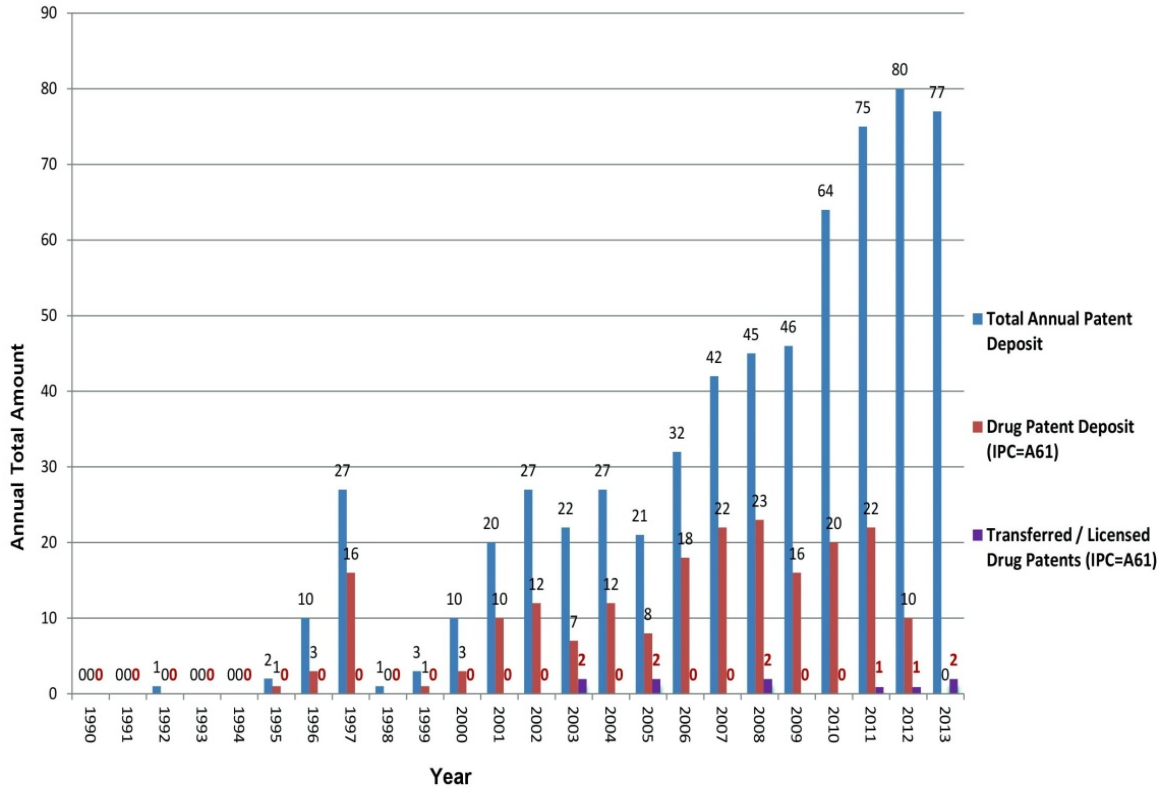


Source: Elaborated by the authors

Graph 4 shows the result of the inquiry into UFMG's contracts exercised by CTIT along the years of study. As such we distinct the annual amount of technology transfer/licensing from other contracts established by CTIT through its "departamento Juridico" (Law department). As such it is shown that in the first decade (1992 -2001) of UFMG's patenting, there was no record of any patent or technology transfer contract. In the second decade of patenting (2002 through 2011), UFMG registered an annual growth of total contracts up to 23 in 2011 while transfer/licensing contracts strived to attain 7 in amount registered in the same year, 2011 and other contract i.e. the non-transfer/licensing contracts reached 16 accordingly. In the third

decade (2012 till date), there was a recent doubled increase in the year 2012 to the maximum of 44 total amount of contracts which remains constant in the following year 2013 whereas, the annual growth of total amount of transferred/licensing contracts increases to 8 in 2012 and 13 in 2013 respectively. Here other contracts are negatively related to transferred/licensing contracts i.e. the higher the transferred/licensing contracts, the lesser the other contracts.

Graph 5 – The Growth Rate of UFMG's Deposited and Transferred / Licensed Drug Patents Compared to Other Patent Deposits and Contracts (1990-2013).



Source: Elaborated by the authors

Graph 5 shows a comparison of the annual growth in amount of patents, drug patents (IPC A61), as well as the annual growth in total amount transferred/licensing of drug patents (IPC A61). Here, the findings of this research show that drug patent has a huge percentage in UFMG's annual amount of deposited patents and transfer and there is a high level of discrepancy between the annual amount of deposited drug patents (IPC A61) and annual amount of transferred drug patent. While the annual growth rate of deposited drug patents (IPC A61) is in its tens, Transfer/licensing of drug patents demonstrates a stunted annual growth rate at the maximum of 2 throughout the years of study.

Despite its position as the third highest depositor of patent in the Brazilian national ranking as at 2010 as shown in table 5, it is observed that the growth rate of patent deposit at UFMG is not any close to its massive publication of scientific articles on yearly bases. Nevertheless, it may be too ambitious to have attempted to equate both variables i.e. Total Scientific Production and Total Patent Deposit as depicted on Graph 2, but this kind of comparison is to provoke a tilt toward patenting culture showing evidence that there exist many researches done in UFMG despite the low rate of deposit.

We may then consider other variables to measuring the performance of UFMG /CTIT in knowledge production and applicability of the generated knowledge to economic growth. For a specific or conjunction of knowledge to be economically viable its worth must be quantifiable monetarily. This upholds the need for identifying the characteristics of a given knowledge and thus its protection on the one hand as an invention or process, through invention patent or utility model, or through the use of other means of protection like preserving it as knowhow to a technology or its process on the other hand.

Given these contingencies, we hereby compare the total amount of patented technologies on annual bases with the growth rate of patented drug technologies as shown on Graph 15. As such, it was discovered that the drug patents i.e. patents with the IPC classification A61 equal 32.3% (204 patents) of the total UFMG's patents and the yearly trend as shown on Graph 15 and only 5% (10 patents) has been successfully transferred. Whereas the national university patent analysis demonstrated that UFMG is the second highest depositing university of drug patent (A61) immediately after the Federal University of São Paulo as earlier demonstrated in this study.

In the course of this study, it was detected that about 195 contracts were established by the CTIT along the years between 1990 and 2013. According to the analyzed data from the law department of CTIT, it was in 2003 that the first set of contracts was recorded. These contracts, whose objects are patent, know-how, trademark, Industrial design, and Software, were established between UFMG and various institutions like universities and industrial companies on diverse economic platforms involving technology transfer, Licensing, Incubation, Co-proprietorship and Research, and Technical Partnership, Technology Tests, etc.

Coherently, we observe that Total amount of Contract has grown at an increasing rate along the years of study, while Transfer and Licensing Contracts grow as well, but at a much slower rate compared to other kinds of contracts established along the year of study.

Finally, the collated data on UFMG's drug patents were compared with patents of other classification as well as the established contracts involving these classes of patents. As such, we discovered that technological transfer is growing slowly along these years, but the transfer/licensing of drug patents is at the barest minimum. The total amount of transferred drug patents is only 10 since the inception of CTIT, being 14.3% of the total transferred patents, 5.1% of UFMG's total drug patents, 3.6% of the total amount of established contracts at CTIT, and 1.1% of the total amount of UFGM's patents which is due to a very low level of the Brazilian pharmaceutical industry's objective towards university-industry innovation which is notably cultural.

Apart from the Licensing and transfer of technology, CTIT has a record of some other contracts along these years of study, which include Research, Technical, and cooperate Partnership in the development of new technologies, Co-Ownership contracts of technologies, Services contracts, Technology Test contracts, Use of didactic material contracts, Incubation Contract, etc. As such, findings of this research show that CTIT portrays a certain level of seriousness and willingness to establish various types of institutional relationships which may contribute to business innovation. Therefore, in a way of awareness creation to interested groups and members of the public, a list of invented technologies (UFMG's Drug patents, as well as others), with which this research is done, should be made available for easy access.

5. Conclusion

This research has been deliberately focused on a broad inter-discipline view. In order to comprehend the complexity of the structure of patenting and transfer of invented technologies generated from domestically produced knowledge and researches in the University, we have delved into observing and defining the structure of each key element to technology transfer in the local and national context.

Economic growth and advancement can be attained by strengthening the links between the University, Industry and the Government, therefore establishing a strong knowledge based economy, where there should be a better and desirable interaction between these three key elements, the University-Industry-Government.

The Brazilian Government invests in education and basic researches through public and private universities, though not as much as the developed countries, but remains the highest investor in its nation. This investment reflects in the government's annual budget and expenditure and as such should have better returns in the local knowledge generation as well as economic, human and social capital and development, as favorable policies are employed to regulate and stimulate the industries towards innovating and investing in technological researches.

Most industries function with a unique culture often distinct from the expected due to their origins, visions, missions, objectives and legal status. Most appear to be influenced by, or inherit foreign operational and strategic culture, which may be sometimes positive or detrimental to the local economic advancement. The pharmaceutical Industry in Brazil therefore has its own structure whereby multinational companies compete with the local companies apart from the necessarily huge investment in basic researches which slims the chances of local companies of competing on equal grounds. Nevertheless, most pharmaceutical companies own laboratories and run some researches independently or in collaboration with the universities since it may be much cheaper.

Technology transfer and licensing is sometimes the fastest solution to technological necessities, and as such, companies go into transfer and/or licensing contracts in the case of a patented technology or know-how which is not patented knowledge but has economic and monetary values attached to it based on its originality and peculiarity.

Nevertheless, the UFMG's CTIT has been working tirelessly to guarantees improvements and bridge the huge gap between the industry and the university. In its contracts, it is glaring that CTIT renders some grooming of many companies operating without R&D segment, as such CTIT becomes responsible for the transferred or licensed technology as well as monitoring of the use in its production process and good negotiating possibilities that entice both big pharmaceutics and small scale industries.

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