CHAPTER 5
INTELLECTUAL PROPERTY, COMMERCIALIZATION AND INSTITUTIONAL ARRANGEMENTS AT SOUTH AFRICAN PUBLICLY FINANCED RESEARCH INSTITUTIONS

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Abstract

Publicly financed research institutions form the largest concentration of skills and personnel in the area of science and technology in South Africa. They are composed of 23 higher-education institutions and five science councils. In 2002, the South African Research and Development Strategy identified disparate practices in respect of ownership, management and commercialization of intellectual property emanating from publicly financed research at these institutions (DST, 2002). Furthermore, the R&D strategy proposed a need for harmonization of IP practices and establishment of a dedicated fund to finance the securing of intellectual property from publicly financed research. This paper explores the state of IP generation and protection at South African publicly funded research institutions from 2001 to 2007, with a view to understanding the current state of patenting by such institutions, the possible constraints that are faced and the institutional arrangements that are currently in place.

The paper, therefore, analyzes the extent of patenting by the institutions both locally (at CIPRO) and internationally (EPO, USPTO and international applications via the PCT). It provides insights into the areas of technology in which South African institutions are patenting, and relies on patent citations to understand the possible economic and technological importance of such patents. The paper also explores the extent of commercialization of the institutions' patents and relies on a survey of the institutions to understand the factors that may be affecting the commercialization of patents and the amounts the institutions have spent on patenting and earned from patent licensing. In addition, a comparative analysis of patenting activity to publication output in respect of the most prolific academic inventors provides some useful insights on the extent to which patenting may affect publication.

Finally, the paper reviews the institutional arrangements for the management of intellectual property and technology transfer at the institutions and various policy initiatives by the Department of Science and Technology (DST). Although it may be too early to judge the exact impact of these initiatives, the study suggests that they are already contributing to changing the culture at these institutions. The paper proposes some goals in order to transform the manner in which research results are handled, and shows an alignment between these goals and the DST's Ten-Year Plan for Science and Technology, aimed at progressing South Africa to a knowledge-based economy.

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The views expressed in this paper are those of the author and do not necessarily represent those of WIPO.

1. INTRODUCTION

South African publicly-financed research institutions (institutions) comprise higher-education institutions and statutory science councils or research institutes. In December 2002, a merger of a number of higher-education institutions was initiated resulting in 23[1] higher-education institutions[2] (see also Table 1). There are five science councils that undertake technological research and development in South Africa, namely the Council for Scientific and Industrial Research (CSIR), Mintek (which specializes in mineral and metallurgical technology), the South African Medical Research Council (MRC), the Water Research Commission (WRC) and the Agricultural Research Council (ARC). Both the MRC and the WRC fund research on a competitive basis, largely at higher-education institutions, with the MRC also undertaking its own research internally.

In 2002, the South African Research and Development Strategy identified disparate practices in respect of ownership, management and commercialization of intellectual property emanating from publicly financed research at these institutions (DST, 2002). Furthermore, the R&D strategy proposed a need for harmonization of IP practices and establishment of a dedicated fund to finance the securing of intellectual property from publicly financed research. Since then, some of the institutions have proceeded to develop and implement IP policies aimed at ensuring certainty in respect of ownership, commercialization and technology transfer of intellectual property developed there.

Since the institutions collectively form the biggest concentration of skills and personnel in the area of knowledge generation, they are likely to be the sources of new knowledge, inventive ideas and inventions and, possibly, patents. It is thus important to get a good understanding of the state of IP generation and protection and the extent to which such intellectual property is converted to useful products and services, so as to determine its potential impact on South Africa's system of innovation and economy.

This paper presents the results of research undertaken on the state of protection, management and commercialization of IP by the institutions over a seven-year review period covering 2001 to 2007. The paper also analyzes the extent of institutional arrangements, including government support for IP management and commercialization. The research was carried out in order to address the following questions in an empirical manner: What is the extent of patenting by the institutions both at local and international IP offices? Are there any specific technology areas which receive the most attention in respect of patenting by the institutions and could these be proxies for technology and research strengths? What is the extent of citation of patents from the institutions? To what extent are they commercializing their patents? What is their mode of commercialization of the patents? What are the factors seen as affecting commercialization of intellectual property, particularly patents, by the institutions? Is patenting hindering scientific development by reducing publication rates? To what extent is the existence of technology transfer offices and IP policies influencing patenting and commercialization of research results at the institutions? What has been the impact of government policy interventions on the IP landscape? What strategic interventions are required to maximize technology transfer of research results from the institutions to industry and society?

This paper is organized as follows. The research methodology is contained in Section 2. Section 3 is divided into four parts. The first part presents the patenting activity by the institutions at the South African Patent Office (CIPRO); the second part looks at patenting activity by the institutions in respect of patent applications filed under the auspices of the PCT and patents granted by the EPO and the USPTO. Particular emphasis was placed on the distribution of patenting activity in terms of the areas of technology as indicated by the IPC system and citation analysis; the third part analyzes the state of commercialization of intellectual property at the institutions with a focus on revenues generated against patent expenditure and also the extent to which start-up[3] companies are used as vehicles for commercialization; and the fourth part reviews the institutional arrangements for technology transfer and institutional policies. Section 4 is a discussion of the various aspects of Section 3 within the context of broader policy perspectives, including research funding and research output as indicated by publication rates of the institutions. Section 4 also presents some lessons and arguments arising from the research and discusses some policy interventions by the DST, aimed at transforming the way in which the institutions handle research. The paper concludes with Section 5, which summarizes the conclusions from the research, with particular emphasis on answers to the specific questions set out above.

2. RESEARCH METHODOLOGY

2.1 Patenting at the Local Level at CIPRO

CIPRO operates on a deposit or non-examining system, which means that as long as formalities have been complied with, a patent will be granted from a complete patent application. Thus, unless an applicant decides not to proceed, a complete patent application that complies with formalities always proceeds to grant.

A provisional patent application is a first filing application which provides a priority date for an invention, i.e. the earliest possible date from which to claim protection for an invention, according to the Paris Convention. In South Africa, a provisional patent application comprises a specification which broadly describes the invention, as opposed to a complete specification which is expected to more clearly define the invention through a set of claims. Following the filing of a provisional patent application, an applicant has a period of 12 (twelve) months to secure final patent protection in Paris Convention member states through the filing of a complete patent application accompanied by a complete specification claiming priority from the provisional patent application, or to file a PCT application claiming priority from the provisional patent application.

Patent abstracts are published in the Patent Journal on a monthly basis by the government printers in the month in which the patent is granted. Manual name-index searches were conducted through the records at CIPRO, using the names of the various South African higher-education institutions and science councils. These searches were supplemented by manual review of the various issues of the Patent Journal published in the review period.

2.2 International Patent Applications and Patents Granted at the EPO and the USPTO

Searches were conducted through the databases of the EPO, USPTO and WIPO[4] for patent applications filed under the auspices of the PCT, and also through the commercial database Micropatent[5] for patents granted at the EPO and USPTO. The searches were conducted using the names of the institutions in the review period, with South Africa as a priority. In respect of the PCT, the results are for patent applications published in the review period, whereas in respect of patents, they are for patents granted during the review period.

The results were analyzed to determine various aspects, including the trend of filing and the areas of technology where the institutions were securing patent protection for their research results. Further, citation analysis was carried out on PCT applications, EPO patents and USPTO patents. Since patent citations can be used as a proxy for the importance and significance of the patents in the area of technology in which they belong (Jaffe and Trajtenberg, 2002), the highly cited patents would generally be expected to have a higher economic and technological importance (Montobbio, 2006).[6] Commercialization details, if any, of the most-cited patents were requested from institutions, to assess the extent, if any, of the economic and technological relevance of the cited patents and also the institutions' efforts to commercialize these patents. Furthermore, inventor analysis was undertaken to determine the most prolific researchers at the institutions, in addition to relating their patent outputs to publication outputs. Interviews were carried out with some of the inventors to understand how patenting had affected their publication outputs.

2.3. Institutional Arrangements and State of Commercialization

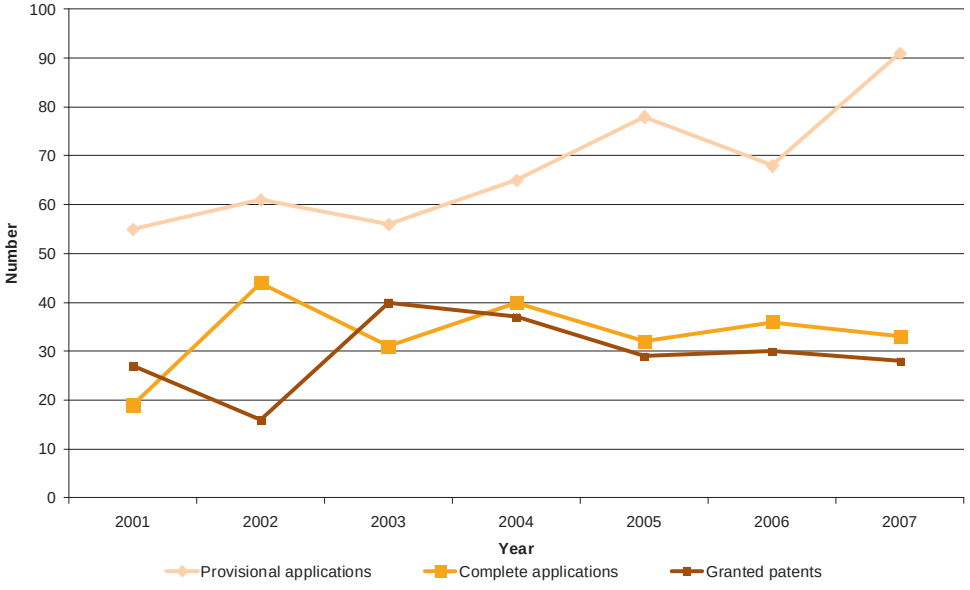
A questionnaire was developed and sent out to all the institutions which either had a technology transfer office or had filed at least one patent application during the review period. The questionnaire was adapted from that used in the Australian study of patenting and commercialization by Australian universities (Singhe *et al*., 2005). The institutions were asked to score the relevance of certain factors in respect of patenting and commercialization at their institutions. Of the 20 institutions to which the questionnaire was sent, responses were received from 14, comprising 11 of the 23 higher-education institutions and three of the five science councils. The mean scores of the various factors listed in the questionnaire were used to measure the relevance of the factors affecting both patenting and commercialization by institutions. In order to better understand the issues that affect institutions' ability to protect and to successfully commercialize such new knowledge, they were requested to provide the following details: year of establishment of the technology transfer office, patenting costs incurred and revenues generated in the review period, number of start-up companies established and whether or not the establishment was associated with a patent.

3. STATE OF PATENTING AND COMMERCIALIZATION BY SOUTH AFRICAN INSTITUTIONS

3.1 Patenting at the Local Level at CIPRO

In an analysis of the CIPRO patent register entries which cite the institutions as applicants, Figure 1 shows that although there has been an increase in the filing of provisional patent applications over the review period, the number of complete patent applications filed at CIPRO by the institutions remained fairly static, as did the number of patents granted to them. The grant of a patent normally takes about six to 12 months from the filing of the complete patent application. Thus, the patents granted in Figure 1 for any given year should be interpreted in relation to the complete patent applications filed in the preceding year.

Figure 1. Patent Applications Filed and Patents Granted to the Institutions at CIPRO in the Review Period



A further analysis of the actual entries indicated that only 20 institutions out of a total of 28 had filed a patent application in the review period. Table 1 summarizes the provisional patent applications, complete patent applications and granted patents filed by them for each year of the review period.

Table 1. Patent Applications and Grants at CIPRO by Institution (2001-2007)

Institution	Patent Type	2001	2002	2003	2004	2005	2006	2007	Total
CSIR	Provisional	16	13	8	14	18	8	11	88
	Complete	6	9	8	6	3	7	7	46
	Grant	3	4	12	12	8	5	2	46
MRC	Provisional	1	1	0	0	0	0	4	6
	Complete	3	2	1	1	0	2	1	10
	Grant	0	2	4	1	3	0	3	13
Mintek	Provisional	8	4	3	2	3	1	0	21
	Complete	2	6	3	3	1	0	2	17
	Grant	4	3	5	4	1	1	1	19
Agricultural Research	Provisional	2	2	0	2	0	0	1	7
Couoncil (ARC)	Complete	1	2	0	1	3	0	0	7
	Grant	1	2	0	1	2	1	0	7
Water Research	Provisional	2	3	1	0	0	5	1	12
Commission	Complete	1	2	0	3	0	0	3	9
(WRC)	Grant	4	1	0	0	1	2	0	8
University of the	Provisional	1	2	1	10	22	14	19	69
Witwatersrand (WITS)	Complete	0	0	0	2	5	2	2	11
	Grant	0	0	0	0	1	0	2	3
University of Pretoria	Provisional	8	7	2	6	3	9	6	41
	Complete	2	5	4	2	1	5	3	22
	Grant	10	2	6	5	1	1	3	28
University of	Provisional	0	0	4	3	0	0	2	9
Johannesburg (UJ)	Complete	0	1	1	0	7	3	2	14
	Grant	0	0	2	1	1	2	7	13
University of	Provisional	10	7	7	6	12	3	4	49
Cape Town (UCT)	Complete	0	2	3	7	4	5	1	22
	Grant	1	0	3	0	4	3	3	14
Nelson Mandela	Provisional	0	1	1	2	0	2	0	6
Metropolitan University	Complete	0	2	2	2	0	1	0	7
(NMMU)	Grant	2	0	1	2	1	0	0	6
Tswane University of	Provisional	0	0	0	1	0	3	6	10
Technology (TUT)	Complete	0	0	0	0	1	0	4	5
	Grant	0	0	1	0	0	1	0	2
University of	Provisional	0	0	0	0	0	1	1	2
KwaZulu-Natal (UKZN)	Complete	0	0	0	0	0	0	0	0
	Grant	0	0	0	0	0	0	0	0
Durban University of	Provisional	0	0	0	0	3	1	1	5
Technology (DUT)	Complete	0	0	0	0	2	4	3	9
	Grant	0	0	0	0	0	0	0	0
Rhodes University	Provisional	0	0	1	1	1	0	0	3
	Complete	0	0	0	0	0	1	0	1
	Grant	0	0	0	0	0	0	0	0
University of Stellenbosch	Provisional	5	14	17	14	9	10	16	85
	Complete	1	5	2	7	2	2	4	23
	Grant	1	1	3	5	2	5	2	19
North West University	Provisional	2	6	10	3	4	4	3	32
	Complete	3	8	6	5	4	4	1	31
	Grant	1	1	3	4	4	3	4	20
University of	Provisional	0	0	0	1	0	0	1	2
Western Cape (UWC)	Complete	0	0	0	0	0	0	0	0
	Grant	0	0	0	0	0	0	0	0
Vaal University of	Provisional	0	0	0	0	0	1	0	1
Technology	Complete	0	0	0	0	0	0	0	0
	Grant	0	0	0	0	0	0	0	0
University of the Free State	Provisional	0	1	0	0	1	0	0	2
	Complete	0	0	1	1	0	1	0	3
	Grant	0	0	0	2	0	3	1	6
Total	Provisional	55	61	55	65	76	62	91	465
	Complete	19	44	31	40	33	37	33	237
	Grant	27	16	40	37	29	30	28	207

Source: CIPRO

From Table 1, it is evident that there is a big variation in patenting activity among the institutions. In the review period, 20 of them filed at least one provisional patent application, with 16 institutions having patents granted by CIPRO.

The CSIR has the highest patenting rate as measured not only by the number of patent applications filed (both provisional and complete applications), but also in terms of patents granted in the review period. The CSIR[7] is a research institution that undertakes research in a variety of disciplines as its main business. The other research institutions that were among the 20 institutions were the MRC which has a mandate for promoting health; the ARC[8] which has a mandate to "conduct research, development & technology transfer in order to promote agriculture and industry, contribute to better quality of life, and facilitate or ensure natural resource conservation"; the WRC with a mandate "to support water research and development as well as the building of a sustainable water research capacity in South Africa":[9] and Mintek[10] which specializes in mineral processing and extractive metallurgy. Mintek had the highest patenting rate after the CSIR, as far as research institutions are concerned.

An analysis of the data for the higher-education institutions showed that the Universities of Cape Town, Pretoria, North West, Stellenbosch and the Witwatersrand have the most important patenting activity among the higher-education institutions. The two latter, while having the highest numbers of provisional patent applications, have a lower conversion rate into complete patent applications. In addition, the table reveals that some of the higher-education institutions that were not patenting at the beginning of the period had began to file patent applications toward the end of the period.

Patent abstracts as published in the *Patent Journal* were analyzed for their classification in terms of the IPC system. A summary of the classification of the South African patents granted to the top 12 institutions is set out in Table 4.

Table 2. Summary of IPC Codes of Patents granted by CIPRO to the Top 12 Institutions in the Review Period

Assignee	A Human necessities	B Performing operations, transporting	C Chemistry and metallurgy	D Textiles paper	E Fixed constructions	F Mechanical engineering, lighting,heating, weapons, blasting	G Physics	H Electricity
CSIR	A23L;A23P; A61B (2); *A61K (3); A62B (2); A45C A71F	B01D (3); B01J (3); B22D; B60P; B62B (2); B65D (3); B67D	C01B(2); C01G; C07B;*C02F (2); *C12P; *C12N; *C12M; C10L; C11B; C07C; C23C; C08F; C22C		E21C; E21D (3); E21B (3); E21F; E05G	F01N; F02G; F25B; F16H; F01B; F41H	*G01N (2)**G01P; **G01B; **G01D; **G01J; **G08B; G01V; **G08C; G02B	**H01L (2); **H04B; **H04N (2); H04G
MRC	A61B (2); A61D; A61P; *A61K (6)A61L		*C07K (4)C07C; *C12N(4); C12Q (2); C22B		E21D		*G01N (3); **G08C	
Mintek		B01J (5); B22D; B22F; B60R	C01G (3); C04B (2); C08J; C22B (8); C22			F15D; F32B	G06K	
ARC	A01N; A23B; A23F	B65B	*C07K; *C12N (4); *C12M					
WRC		B01D	C02F (7)				**G01B	
University of the Witwatersrand	A61B; *A61K (2)				E04B			
University of Pretoria	A01G; A61B (3); *A61K (4); A61N; A61P (2); A61Q; A62C (2); A62D	B01J; B06B	C01B (2); C01F; C08L; C23F; C09K (2); C07C (3); C09D; C22B; C01G (3); C06B; C07F; *C12N		E04B; E04C; E04H	F02M; F16SF16F; F21V; F23Q; F42B	**G02B; **G04B; **G06F; **G09B; **G06F; G21F	**H01L(3); **H01P **H01S; **H04M
University of Johannesburg		B23B; B25F	C07C; C07D; C08G	D21B; D21F	E04B		G01N (2); G01L; **G06K	H04B; H01L (2)
University of Cape Town	A61F (2); A01N; A23L	B03B (2); B03D (2)	C02F; C22B; C07C; *C07K; *C07K; *C07 *C07K; *C07K; *C12N; *C12N				G01D; G22B; **G01N	
NMTU		B23K; B29C	C07B (2); C07C (3)				**G01L; **G01B	H01M
University of Stellenbosch	A01C (2); A01G; A01H (2); A23B; A23F; A23L (2); A61B; A61D; *A61K (2)	B01D; B01L; B65D	C01F; C05F; *C07K (2); *C12N (6); C08F *C12P (3); C07H; C12G; *C12Q; C13K; C22B				G01J; *G01N (2); G01R; G06F	**H01J; *H04B; H02J; H02H; H02B; H02G; **H03C;**H03K
University of North West	A01G; A61C	B01D (3); B02C; B32B; B64B	C01B; C05F;C07B; C08L; C08K; C23F; *C12N; C22B; C09K		E05B	F03D	**G01F;**G01R; **G01V; G06F	**H03F; **H03K

1 The numbers in brackets represent the number of patent documents with the same classification. Where a document had more than one classification, all the classifications are included in the Table.
2 The summary of IPC codes is based on classification of the patents as per patent abstracts. Where an abstract did not have a classification, we have not attempted to classify the patent.
3 Biotechnology*; Information Communication Technology (ICT) **, as per classification in OECD (2007).

As can be seen from Table 2, the patents granted to the institutions were in the following areas of technology (as per the IPC), in decreasing order of quantity: C (chemistry and metallurgy), A (human necessities); B (performing operations, transport); G (physics) and H (electricity); E (fixed constructions); F (mechanical engineering, lighting, heating, weapons, blasting); and D (textiles, paper). A more in-depth analysis further revealed that a large number of the patents were in life sciences/biotechnology and ICT (see Table 2).

The CSIR has the broadest patent portfolio, consistent with the fact that it "undertakes directed and multidisciplinary research, technological innovation as well as industrial and scientific development" in eight broad research focus areas covering biosciences, information technology, material science and engineering, laser technology, space technology, natural resources and environment, defense and built environment. The patents in the name of the MRC are predominantly in the life sciences/biotechnology sector, as would be expected in line with its mandate of health research.[11] Mintek's portfolio of patents is in C22B (production or refining of metals; pre-treatment of raw materials), which is consistent with Mintek's mandate "to serve the national interest through research, development and technology transfer, to promote mineral technology and to foster the establishment and expansion of industries in the field of minerals and products derived therefrom". The WRC's patent portfolio is primarily in C02F (treatment of water, waste water, sewage or sludge), in line with its mandate of funding and promoting water research.

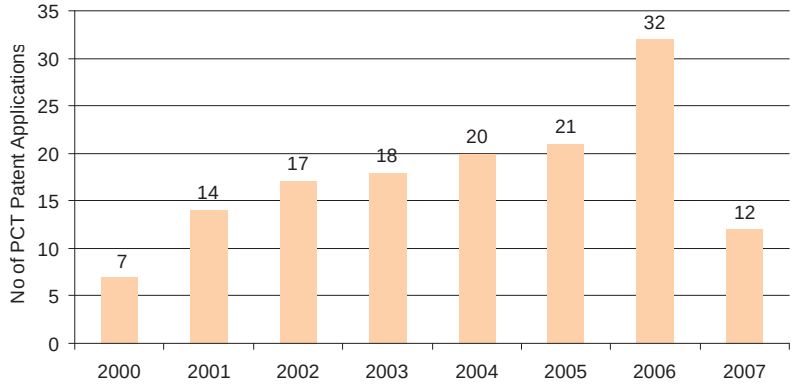
Most of the patents from the University of Stellenbosch were in the life sciences/biotechnology sector (OECD, 2007), with the next highest number of patents in ICT. The patents from the University of Pretoria and the North West University were predominantly in ICT. Similar to the University of Stellenbosch, the University of Cape Town's patents were predominantly in the area of life sciences/biotechnology. Owing to the fact that no classification data could be obtained for provisional applications (there is no requirement to classify provisional applications in South Africa) and complete patent applications filed at CIPRO, we were unable to determine whether there was a difference between areas of technology of patent applications and granted patents.

3.2. Patenting by the Institutions at the EPO, USPTO and WIPO

3.2.1 PCT Applications

In the review period, 141 PCT patent applications claiming priority from at least one South African application were published in the names of the institutions. Figure 2 shows the pace of filing of the published applications.[12]

Figure 2. Pace of Filing of PCT Applications by the Institutions



Source: PatentScope®, WIPO

Table 3 shows the distribution of the 141 PCT applications among the institutions. The top three higher-education institutions, namely the Universities of Cape Town, North West and Pretoria had a publication rate ranging from 1.7 to 3.29 applications a year, respectively, compared with the CSIR's 5.71 applications a year.

Table 3. Top Institutions by PCT Patent Applications with a South African Priority

Assignee	Document Count
CSIR	40
University of Cape Town	23
North West University	18
University of Pretoria	12
Mintek	10
South African Medical Research Council (MRC)	10
University of Johannesburg	9
University of the Witwatersrand	9
Agricultural Research Council (ARC)	5
University of Stellenbosch	5
Nelson Mandela Metropolitan University	3
Total PCT applications	141

Table 4 summarizes the top 10 IPC subclasses in respect of the 141 PCT applications. An analysis of the top five IPC subclasses indicates that 25.5 per cent of the applications were in medicinal or veterinary sciences and hygiene (A61K and A61P), micro-organisms or enzymes (C12N) and organic chemistry (C07K).

Table 4. Summary of the Fields Covered by the PCT Patent Applications with a South African Priority in the Names of the Institutions

IPC Subclass	Description of IPC Subclass	Document Count
A61K	Preparations for medical, dental or toilet purposes.	25
C12N	Micro-organisms or enzymes.	21
C07K	Peptides.	17
A61P	Therapeutic activity of chemical compounds or medicinal preparations.	11
G01N	Investigating or analyzing materials by determining their chemical or physical properties.	10
C12P	Fermentation or enzyme-using processes to synthesize a desired chemical compound or composition or to separate optical isomers from a racemic mixture.	7
B01J	Chemical or physical processes (e.g. catalysis, colloid chemistry); their relevant apparatus.	6
C22B	Production or refining of metals; pre-treatment of raw materials.	6
C08L	Composition of macromolecular compounds.	5
C09D	Coating compositions (e.g. paints, varnishes, lacquers); filling pastes; inks; woodstains; pastes or solids for colouring or printing; use of materials therefor.	5
Number of occurrences in top 10 patent classes		113
Total number of IP subclasses		237
Total number of documents in group		141

Citation Analysis

Forward citation analysis was carried out on the 141 PCT applications to determine the extent to which any of them were cited by other patent applications and/or patents, and hence a proxy for their economic and technological importance.[13]

According to Table 5, nine of the 141 PCT applications were cited at least three times, with the leading document cited seven times. Of the top 10 most-cited PCT applications from the institutions, six were from higher-education institutions. According to enquiries at the institutions concerned, the most-cited patent (WO2002096393) is the only one that has been licensed so far, namely to Sportron International (Pty) of South Africa.

Table 5. Most-Cited PCT Applications with a South African Priority, in the Names of the Institutions

Document ID	Assignee	Title	Year Issued	Cited by
WO2002096393	North West University	Anorexic composition comprising calcium acetate	2002	7
WO2002016272	CSIR	Water treatment method	2002	5
WO2002004494	MRC	Process for the selection of HIV-1 subtype C isolates, selected HIV-1 subtype isolates, their genes and modifications and derivatives thereof	2003	4
WO2002092162	University of Stellenbosch	Radiation application method and device	2004	4
WO2001080550	CSIR	A panoramic camera.	2001	3
WO2003059507	Mintek	Gold catalysts and methods for their preparation	2003	3
WO2003006956	University of the Witwatersrand	Cell enumeration	2003	3
WO2001000554	University of Pretoria	Naphthoquinone derivatives and their use in the treatment and control of tuberculosis	2001	3
WO2003002126	University of Pretoria	Anti-retroviral agent in combination with tea polyphenol for the treatment of viral infections	2003	3
WO2003104675	University of Pretoria	Vibration isolator	2003	2
Number of citations in top 10 documents				37
Total number of documents in the group				141

3.2.2 EPO Patents

Twenty-three EPO patents were granted to South African institutions during the review period. The distribution of the EPO patents among the institutions is set out in Table 6. The CSIR leads the table with 11 granted EPO patents, with North West University leading the higher-education institutions with four granted patents.

Table 6. Top Institutions in Terms of EPO Patents Granted to the Institutions

Assignee	Document Count
CSIR	11
Mintek	4
North West University	4
University of Pretoria	2
University of Stellenbosch	1
University of Johannesburg	1
University of Free State	1
South African Medical Research Council (MRC)	1
Total EPO patents	23[14]

IPC Codes and Citation Analysis

The analysis of the IPC subclasses of the 23 EPO patents indicated a lack of significant portfolios, in that no single IPC subclass had more than two documents. However, a review of the most-cited IPC subclasses reveals that at least 25 per cent of the patents were in the area of life sciences/biotechnology (A61K, A61P and C02F). From Tables 4 and 6, it is apparent that A61K, A61P and C22B are the only IPC subclasses that are common to the PCT applications and the EPO patents.

Table 7. Summary of the Most-Cited IPC Subclasses in Terms of EPO Patents in the Names of the Institutions

IPC Subclass	Description of IPC Subclass	Document Count
A61K	Preparations for medical, dental or toilet purposes.	2
A61P	Therapeutic activity of chemical compounds or medicinal preparations.	2
C02F	Treatment of water, waste water, sewage, or sludge.	2
C21C	Processing of pig-iron (e.g. refining, manufacture of wrought-iron or steel); treatment in molten state of ferrous alloys.	2
C22B	Production or refining of metals; pre-treatment of raw materials.	2
Total number of documents in group		23

None of the 23 EPO patents received forward citations. This could be due to a number of factors such as a somewhat more protracted prosecution process at the EPO, and also differences in examination procedures and prior-art disclosure requirements between the EPO and, for example, the USPTO, which appears to result in lower citations in EPO patents as compared with USPTO patents (Montobbio, 2006). Other reasons could be that these patents are of very little economic and/or technological relevance within their fields, or that they are too recent and their full technological value is as yet unclear.

3.2.3 USPTO Patents

In the review period, 29 patents were granted by the USPTO to the South African institutions. Similar to the EPO patents, both the CSIR and North West University had the most patents in respect of science councils and higher-education institutions, respectively (see Table 8). As can also be seen from Table 8, only two other higher-education institutions, namely the Universities of Pretoria and Stellenbosch were granted patents by the USPTO during the review period, each with two patents. The Water Research Commission has also been very active in patenting in the US, with four patents in the review period.

Table 8. Top Institutions by USPTO Patents in the Names of the Institutions

Assignee	Document Count
CSIR	15
North West University	4
Water Research Commission	4
University of Pretoria	2
University of Stellenbosch	2
Mintek	2
South African Medical Research Council (MRC)	1
Total USPTO patents	29

IPC Codes over a Period of Time

The most-cited IPC subclasses in respect of the USPTO patents are summarized in Table 9. Other than A61K and C02F (biotechnology) which featured in the top list of IPC subclasses in respect of the EPO patents, C01B and G01N were cited on at least three and two patents respectively.

Table 9. Summary of the Most-Cited IPC Subclasses on USPTO Patents in the Names of the Institutions

IPC Subclass	Description of IPC Subclass	Document Count
C02F	Treatment of water, waste water, sewage or sludge.	7
A61K	Preparations for medical, dental or toilet purposes.	3
C01B	Non-metallic elements; compounds thereof.	3
G01N	Investigating or analyzing materials by determining their chemical or physical properties.	2
Total number of documents in group		29

Citations Analysis

Citation analysis of the USPTO patents indicated higher citations compared with both the PCT applications and EPO patents (which had no citations) (see Table 10). This could be due to patent prosecution requirements in the US in respect of information disclosure (Montobbio, 2006). No higher-education institutions have cited patents. Other than having the most-cited USPTO patent, the CSIR has a total of six patents in the top 10 most-cited USPTO patents in the names of the institutions, followed by Mintek and the Water Research Commission, each with two patents. Of the 10 patents included in Table 10, three have been licensed.

The most-cited patent (US6376657) of the CSIR, was the object of a license agreement to Phytopharm,[15] while patents US6228263 and US6197196, owned by the Water Research Council, have been licensed to East Rand Water Care Company. The other patents have not yet been the object of a license. Interestingly, both inventors cited on the WRC patents were full-time researchers at Rhodes University (which did not have a policy on IP ownership – see Table 11 below) undertaking research funded by the WRC at the time of filing of the patent applications.

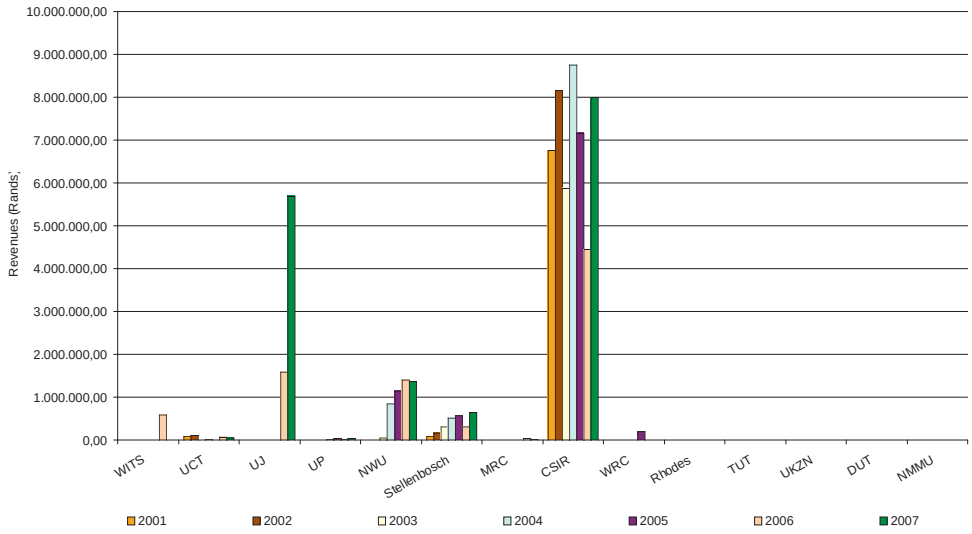
Table 10. Top 10 Most-Cited USPTO Patents in the Names of the Institutions

Document ID	Assignee	Title	Year Issued	Cited By
US6376657	CSIR	Pharmaceutical compositions having appetite-suppressant activity	2002	12
US6221399	CSIR	Method of making controlled release particles of complexed polymers	2001	10
US6306302	CSIR	Process for treatment of sulphate-containing water	2001	6
US6490881	CSIR	Generating displacement and thermoacoustic refrigerator	2002	5
US6419834	CSIR	Treatment of acidic water containing dissolved ferrous cations	2002	4
US6228263	WRC	Treatment of sulphate-and metal-containing water	2001	4
US6592246	CSIR	Method and installation for forming and maintaining a slurry	2003	2
US6197196	WRC	Treatment of water	2001	2
US6699302	Mintek	Treatment of metal sulphide concentrates by roasting and electrically stabilized open-arc furnace smelt reduction	2004	1
US6287362	Mintek	Production of metal lumps and apparatus therefor	2001	1
Number of citations in top 10 documents				47
Total number of documents in the group				29

3.3. Commercialization of Intellectual Property by the Institutions

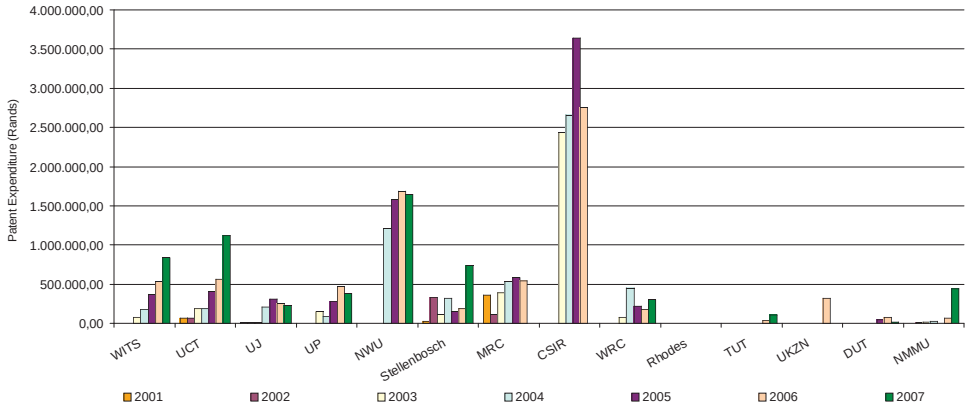
As explained in Section 2.3, a survey questionnaire was sent to the 20 institutions, which either had a technology transfer office or had filed at least one patent application during the review period, to enquire further about their commercialization and technology transfer activities, for which 14 replies were received. Based on that survey, only a few institutions generate revenues from commercialization of their intellectual property, particularly patents. Figure 3 summarizes revenues generated by the institutions in the review period. Other than the CSIR and the Universities of Johannesburg and North West, none of the other institutions generated revenues in excess of one million rand[16] in any of the years in the review period. Most higher-education institutions received no revenues from their patents. Figure 4 summarizes the patent expenditure by the institutions in the review period. A comparison of patent expenditure and commercialization revenues generated shows that for most institutions, there has been little success in commercialization of their patent portfolios, if success is to be measured by commercialization revenues.[17]

Figure 3. Commercialization Revenues Generated by Institutions



Source: Survey of institutions

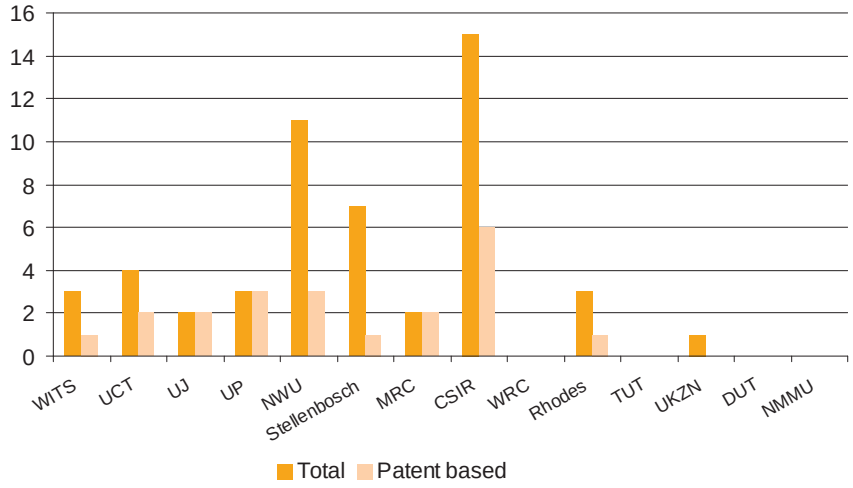
Figure 4. Patent Expenditure by the Institutions



Source: Survey of institutions

Figure 5 shows the number of start-up companies established from institutional intellectual property during the review period. It is evident from this that there is a low rate of establishment of start-up companies. Generally, less than half of the start-up companies are based on patents, with know-how and technology packages playing a more significant role in their establishment. For most of the institutions, start-up companies are not viewed as being a practical mechanism for commercializing patents, with most of the institutions preferring licensing instead. Those, particularly the higher-education institutions, regard technology transfer through the establishment of start-up companies as being very risky as they would often be expected to contribute to further funding needs. The institutions are also increasingly under pressure to generate revenues from their intellectual property, and the establishment of a start-up company would amount to "deferred revenues". The lack of strong patent portfolios that could form the basis for strong and potentially high growth start-up companies, if they are able to attract substantial investments required to further develop the patent portfolio, has, in our view, contributed to the low rate of start-up companies based on patents. The dearth of entrepreneurial researchers who have an appetite for following through on their inventions via a start-up company has also contributed to the low number of start-up companies based on intellectual property from the institutions. This is also related to the differing views on their role, particularly the higher-education institutions. The sentiment among researchers at the latter suggests that their researchers are still grappling with the tension between the universities' primary role of knowledge generation and graduate training and the increasing role of technology transfer to ensure that knowledge generation is within a socio-economic context.

Figure 5. Start-Up Companies Established in the Review Period



Source: Survey of institutions

3.4. Institutional Arrangements

Table 11 summarizes the institutional arrangements for IP management at the institutions at the end of 2007. It is evident that most of them do not have the required infrastructure to manage the process of invention disclosures, filing of patent applications and technology transfer. Of particular concern is the lack of relevant policies in respect of IP issues at most of them, particularly at the higher-education institutions.

A subjective assessment has been made in respect of the skills and capacity at the institutions. In some cases, we have concluded that there is limited capacity, based on the skills and experience of their personnel at those with technology transfer offices. For example, where there is only one person with an IP background but with little or no commercialization experience, we have concluded that there is limited capacity. Similarly, the same conclusion has been reached where there is one person with commercialization experience but no one with an IP background.

Table 11. Summary of Institutional Policies and Arrangements for IP Management, Commercialization and Technology Transfer

Institution	IP Policy	Tech. Transfer Capacity (Year Established)	Institution	IP Policy	Tech. Transfer Capacity (Year Established)
University of Cape Town	Yes	Limited (2002)	University of Pretoria	Yes	Limited (1996)
University of Stellenbosch	Yes	Yes (1999)	North West University	Yes	Yes (2003)
Nelson Mandela Metropolitan University	Yes	Limited (2007)	University of the Witwatersrand	Yes	Limited (2003)
Rhodes University	Yes	No	University of Limpopo	No	No
Walter Sisulu Metropolitan	Yes	No	Tshwane University of Technologie	Yes	Limited (2005)
Durban University of Technology	No	No	University of KwaZulu-Natal	No	In process of establishment
University of Fort Hare	No	No	UNISA	No	No
Cape Peninsula University of Technology	No	No	University of Western Cape	No	No
Vaal University of Technology	No	No	CSIR	Yes	Yes (2001)
University of Johannesburg	Yes	Limited (2004)	Water Research Commission (WRC)	Yes	Limited (2003)
Central University of Technology	No	No	University of Forthare	No	No
Mangosuthu University of Technology	No	No	University of Zululand	No	No
Vaal University of Technology	No	No	Agricultural Research Council (ARC)	Yes	No
Medical Research Council (MRC)	Yes	Yes (2004)	Mintek	Yes	Limited

Source: Survey of institutions

In general, technology transfer offices in South Africa are relatively new, having been functioning on average for approximately three years. The more established offices at the Universities of Cape Town, Stellenbosch and Pretoria have seen a turnover of staff, thus significantly impairing their ability to consolidate the experience and lessons learnt to strengthen their activities. What we have observed is that the more successful technology transfer offices are those in which trust has been established between the technology transfer professionals and the researchers. This is often under-estimated, and our discussions with some of the top academic inventors indicated that trust is based on the ability of the technology transfer professionals to demonstrate empathy with the researchers' challenges and on being able to proactively assist the researchers extract maximum value from their research. A high staff turnover has a negative effect on the establishment of this trust.

On average, the technology transfer offices in South Africa have around two professional staff members compared with 8.7 in Europe (Arundel and Bordoy, 2007). Most of these offices operate as stand-alone cost centers within the institutions. At the University of Cape Town, the technology transfer office forms part of the research office whereas at the University of the Witwatersrand it forms part of Wits Enterprise (Pty) Ltd., which has as its mandate, the generation of "third stream income" for the uni-

versity. Whereas there may be some merit in respect of having the technology transfer office as part of an office with a broader mandate, these activities could receive less attention, as more focus will invariably be placed on activities that bring in money in the short to medium term, i.e. contract research in the case of the University of Cape Town and short courses in the case of the University of the Witwatersrand, with the result that technology transfer activities, which require more effort and time, receive less attention.

4. DISCUSSION

4.1. Patenting Activity

In general, there is a low rate of patenting by South African institutions at both local and international levels. Science councils, particularly the CSIR, have significantly higher patenting rates than higher-education institutions. This is consistent with findings in Europe where it was established that public research organizations have a relatively higher number of patents than universities (Montobbio, 2008).

By international standards, South African higher-education institutions generally have very low patenting activity which appears to mirror a stagnant research output from these institutions as indicated in publications by the available data on scientific publications. (See Chapter 1 by Kaplan for an analysis of this issue.)

A review of patenting activity by institutions at CIPRO revealed a concentration of patents in classes that may be linked to the life sciences/biotechnology and ICT. This is consistent with the findings of Geuna and Nesta (2006) that "broadly defined the research area of biotechnology and pharmaceuticals tends to be an area of extremely high university patenting activity across countries". This, as pointed out by Montobbio (2009) could be due to growing opportunities in the biomedical and ICT sectors or to the fact that the results of university research in the area of pharmaceuticals, communications and electronics are conducive to R&D projects which require clearly defined intellectual property (Montobbio, 2009). The other reason for a relatively high patenting rate in the life sciences/biotechnology sector could be attributed to significant funding by the government pursuant to the formulation of the biotechnology strategy (DST, 2001) which allocated a total amount of 450 million rand over a three-year period for establishment and funding of biotechnology regional innovation centers (BRICS). This funding was in addition to over 100 million rand which, according to its various annual reports, the Innovation Fund[18] provided for life sciences/biotechnology-related projects during the review period. According to Gastrow (2008), of the 454 million rand spent on biotechnology R&D in South Africa in the 2005/2006 financial year, the higher-education spend was the greatest (approximately 39 per cent of the total), with science councils spending approximately 28 per cent.

The extent of patenting appears to be dependent on the type of research being undertaken by each institution, which is often influenced by the mandate of the funding agency.

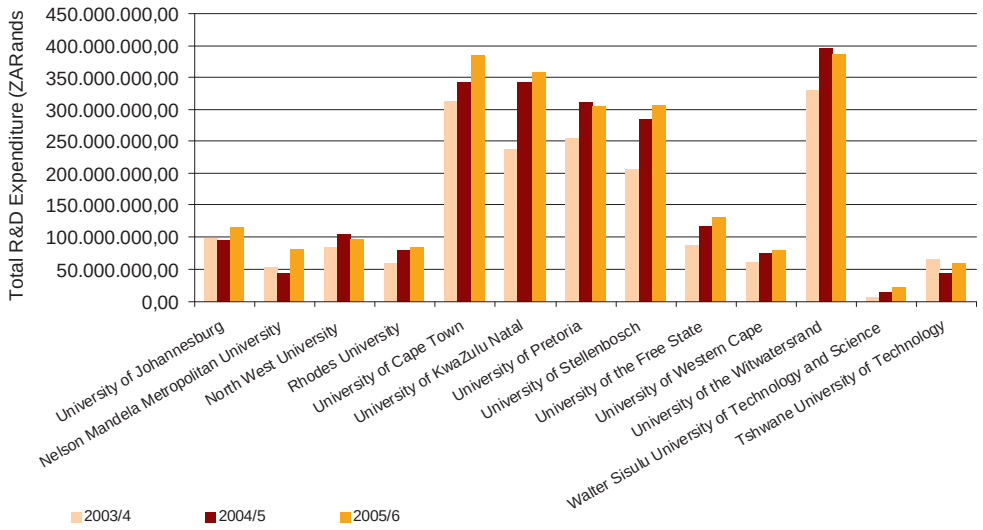
4.2. Patenting Activity as a Function of Institutional Arrangements, Research Expenditure and Publication Rate

There appears to be a correlation between patenting activity and the existence at the institutions of IP policies and institutional arrangements for the management and commercialization of intellectual property, with institutions having arrangements and policies in place recording higher proportions of PCT patent applications, EPO and USPTO patents. This finding is consistent with the findings in Garduno (2004) on South African institutions and also with the review carried out by Nicola (2006), that a supportive environment inside a university is important to stimulate patenting and licensing activities. Interviews revealed that patent data in the names of the institutions may not necessarily reflect the full complement of intellectual property emanating from them, particularly the higher-education institutions, as some of the patent applications could have been filed in the names of the individual researchers, particularly where there were no policies regarding IP ownership (see Table 11). This would be an interesting area for further research.

Generally, the technology transfer offices at the institutions are under-resourced, thus explaining not only the low disclosure rates which result in the low patenting rates, but also the low conversion of patents to commercial products and/or licenses. One of the challenges faced by technology transfer offices, particularly at the higher-education institutions is the increasing pressure to generate "third stream" income in the wake of reduced government subsidies. This may adversely impact on the focus of the technology transfer offices. Instead of focusing on getting institutional intellectual property out into the market place, these offices may increasingly find themselves under pressure to generate income, with the result that relationships with industry may be affected, as the institutions may adopt more aggressive approaches to negotiating licenses and technology transfer. The fact that technology transfer is at a fairly nascent stage in South Africa means that there will also be differences among the institutions as to why they need to embark on it. The lack of institutional policies in respect of IP ownership and commercialization, including benefit-sharing, appears to have contributed to low patenting and commercialization activities at the institutions.

Cloete *et al.* (2006) are of the view that one of the reasons for the low patenting activity by South African scientists is that "research has not been carried out with commercialization in mind and has, therefore, lacked market focus". Although we were unable to verify this assertion, the low rate of commercialization of the patents arising from higher-education institutions appears to support it. Another reason can be the low research capacity of the South African higher-education institutions.[19] This is supported by the fact that patenting activity at most of the major established higher-education institutions (Jacobs and Pichappan, 2006), with reasonable research capacity and substantial funding for research and development (see Figure 6), substantively mirrors that of publication outputs (see Figure 7), with the University of the Witwatersrand, the University of KwaZulu-Natal and the Free State University being anomalies.

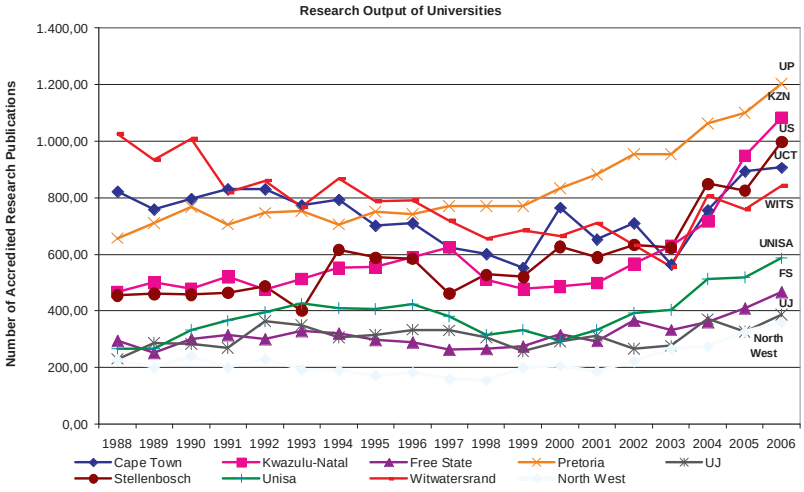
Figure 6. Research and Development (R&D) Expenditure for Selected Higher-Education Institutions



Source: Human Sciences Research Council

The anomaly in respect of the Universities of Kwa-Zulu Natal and the Witwatersrand can be attributed to a lack of a policies in respect of IP ownership, which could explain the high publication output and almost negligible patenting activity, as the individual researchers may have retained ownership of intellectual property generated from their research or simply not applied for IP protection at all.

Figure 7. Research Output by Publication, of Selected South African Higher-Education Institutions



Source: Pouris, 2008

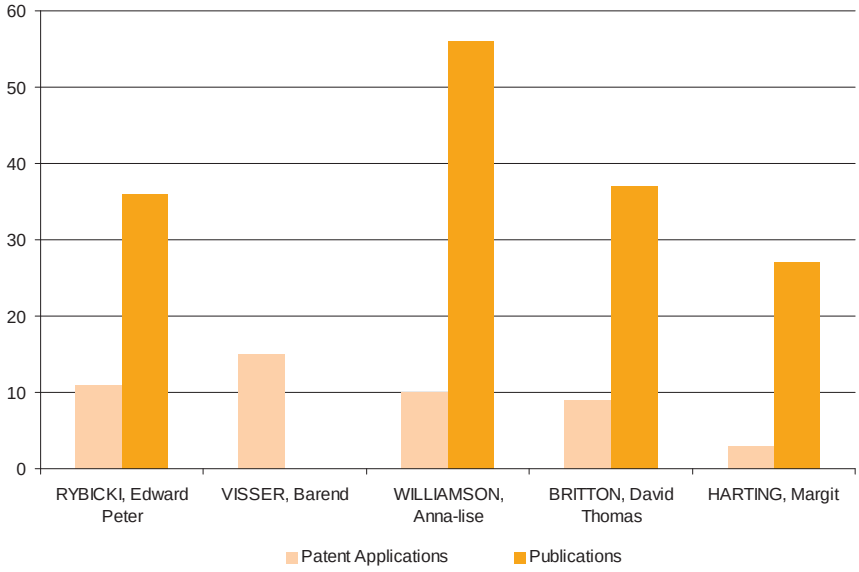
Figure 7 suggests increasing research output by publications since 2003 for the major higher-education institutions. Overall, the number of publications per higher-education institution is greater than the patent applications filed and/or granted. One possible explanation for this misalignment is the fact that publications, as opposed to patents, form the core of subsidy determinations at higher-education institutions by the Department of Education and also promotion of academics at these institutions.

As stated by one of the respondent higher-education institutions: "There is a disjuncture between the policy approaches of the Department of Education (DoE) and the Department of Science and Technology (DST), with the DoE supporting and promoting the traditional outputs i.e. publication in peer-reviewed journals while the DST's main emphasis is on the impact of scientific endeavor in the lives of South Africans. (...) not sure if there is acceptance of the emerging role of higher-education institutions as significant contributors to economic growth and development over and above the traditional role of producing qualified graduates and publications."

Interviews were undertaken with the top five academic PCT inventors who indicated that the adverse effect that patenting has on publication is in respect of publication delays necessitated by a need to comply with novelty requirements of patentability. In some cases, where there were protracted delays, some of the publications had to be abandoned as the results had either become obsolete or there was better data. It does appear that whether to prioritize publication or patenting is wholly dependent on a variety of factors, including the type of research being undertaken, and also the area of technology, with more commercial or market-focused research being more prone to patenting, and possibilities of publication depending on whether the research results can be suitably packaged for a publication.

Figure 8 shows a comparison of patent applications (PCT, EPO, and USPTO) filed by the top five academic inventors with their publication outputs in the review period. Most of the academic inventors had a three-fold publication rate compared with patenting rates, which suggests, particularly in light of the low patenting rate, that it may not be possible to categorically conclude that patenting adversely affects publication, although the issue would need to be studied further using more rigorous techniques. We support the view expressed by one of the top academic inventors that "it is not clear if, in the long term, there will be a negative impact on publication record, but in the short term there are inevitable delays in preparing papers for submission as well as pressures against publishing" as researchers and their technology transfer professionals get to grips with IP management, and in particular, patenting strategies. According to North West University,[20] the reason that Visser had no publications in the review period is not surprising as most of his research work has been on applied research or product development and less on basic research which as indicated above, generally appears to be more suited for publication.

Figure 8. Patent Applications (PCT, EPO, USPTO) and Publications for Selected Inventors from Higher-Education Institutions



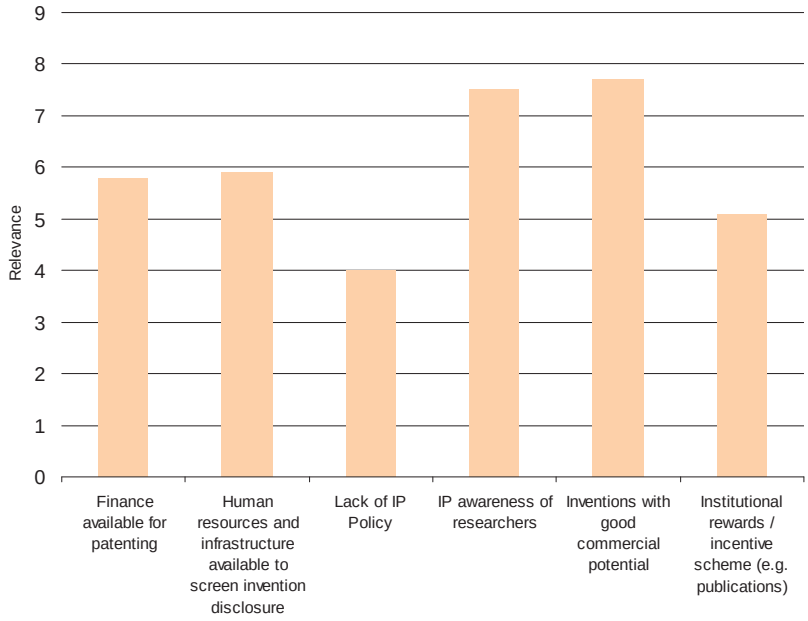
Source: Searches and survey of top inventors

By understanding the patenting time-lines, we are of the view that the perceived delays to publication caused by patenting could either be avoided or at least minimized (Sibanda, 2007). A recent study of patenting by academics (Lubango and Pouris, 2007), which found that those with prior industry experience had a higher propensity to patent, suggests that it is possible to successfully manage the tension between patenting and publication, such that both objectives are attained. It is likely that academics with some prior industry experience, or who can rely on an experienced technology transfer office, would be better able to manage this process.

4.3. Factors Affecting Patenting and Commercialization According to Institutions

According to the institutions, the three most important factors that affect patenting were: (i) commercial potential of inventions; (ii) IP awareness of researchers; and (iii) availability of human resources and infrastructure to screen invention disclosures (see Figure 9). It is worth noting that in the institutions where technology transfer offices were embedded within research offices, one of the issues raised was the financing of patenting, as they still have to bear part of these costs (see discussion of government interventions below).

Figure 9. Factors Affecting Patenting at Institutions



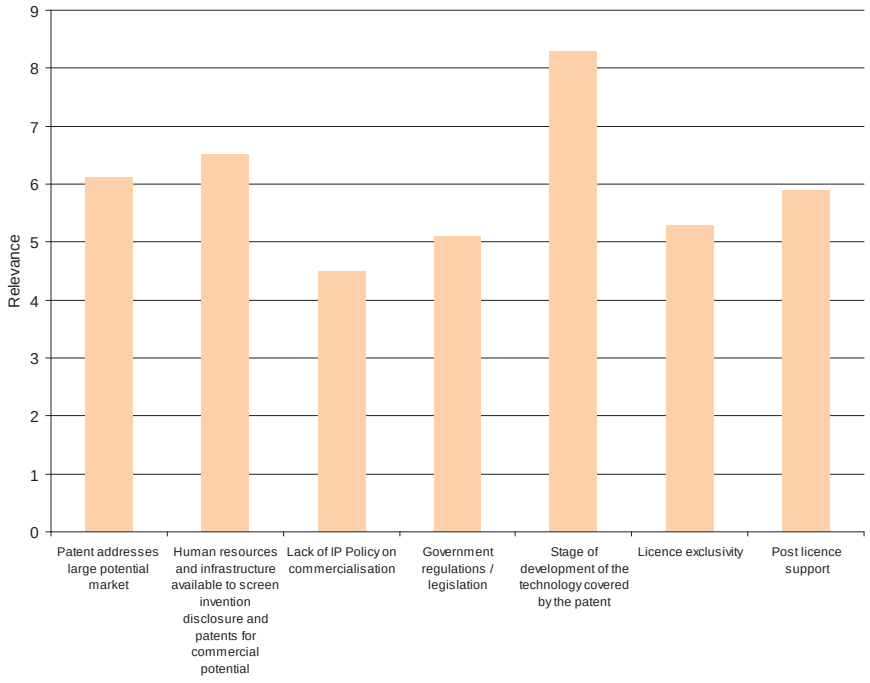
Source: Survey of institutions

Regarding commercialization or technology transfer, the institutions generally exhibit low conversion of patents to licenses and/or start-up companies. If one takes the definition of technology transfer as being the process of transferring knowledge and technologies developed at research institutions to the private sector (Garduno, 2004), within the institutions this process is varied and perceived as being complex. From the interviews, it was also evident that not all revenues were generated from patent-based technologies. In some cases, as illustrated in Figure 9, revenues were generated from non-patented technologies. Other mechanisms of transferring research results to industry, which did not form the subject of this research, but which we believe occur at the institutions, include training of graduates and students, publications, consulting and contract research.

According to the institutions, the three most important factors affecting commercialization of patents were: (i) stage of development of the technology; (ii) availability of human resources and infrastructure to screen invention disclosures for commercial potential; and (iii) the extent to which the patent addresses a large potential market (see Figure 10). Other than the factors set out in Figure 10, the institutions believe that the following factors have also impacted on their success in converting patents to licenses and/or commercial products: (i) "a lack of a system that supports venture creation where technologies are disruptive technologies or fill a space where there are no current licensees available; (ii) dearth of venture capital investors who really understand the technology offering; (iii) lack of entrepreneurial skills to take a new technology to market

through a start up; (iv) a small home market that is available to support a new start up; and (v) lack of seed funding for preliminary proof-of-concept work to increase success of licensing/technology transfer."

Figure 10. Factors Affecting Commercialization of Patents at Institutions



Source: Survey of institutions

4.4. Technology Transfer Activities at the Institutions

In recent years, however, the South African public has started asking what the benefits are of funding research at the institutions. There are increased expectations on the institutions not only to be knowledge generators but also to protect that knowledge and ensure that it contributes to economic development and solving various social challenges relating to health, food, energy and poverty alleviation. Institutions in responding to these expectations are faced with: (i) different views in respect of their role in society, particularly the higher-education institutions; (ii) lack of understanding of IP issues; (iii) where there is some understanding there are different, often untested approaches to IP protection and management; (iv) dearth of entrepreneurial skills and human resources to facilitate technology transfer; and (v) different views as well as expectations about technology transfer.

A comparative study of technology transfer activities in Europe and the US (De Juan, 2002) suggests that successful technology transfer requires a regulatory and institutional support framework which must include policies regarding: (i) the ownership of new technology; (ii) protection of new technology; (iii) the transfer of new technology. Hurlin (1985) in his study of management of technology developed at South African universities observed that: (i) proper use of the patent system could result in additional publications for the researcher; (ii) patents could facilitate transfer of new technology to industry; (iii) although publications could be delayed by a year or so to obtain patent protection, the patent system has the benefit of securing the researcher a far earlier date for his/her work; and (iv) the transfer of technology to industry is a complex function requiring diverse skills, some of which may have to be sourced from outside the university. This paper has indeed demonstrated how complex the institutions are finding this function and also the need to develop the diverse skills required for technology transfer.

Garduno (2004), in a study of South African universities, concluded that in addition to having policies in respect of ownership of intellectual property, universities had to set up an institutional framework appropriate to technology transfer. The Bill that is currently under consideration (IPR-PFRD Bill, 2008) requires institutions to establish a designated office of technology transfer[21]. Whereas there is merit in advocating the establishment of offices of technology transfer at the institutions, the impending legislation also acknowledges the fact that not all of them will necessarily have fully fledged offices "unless determined otherwise by the Minister in consultation with the Minister responsible for higher-education, or any other Cabinet Minister to which an institution reports, any institution must, within 12 months of the coming into effect of this Act: (a) establish and maintain an office of technology transfer; or (b) designate persons or an existing structure within the institution to undertake the responsibilities of the office of technology transfer". The Bill also proposes a concept of "regional technology transfer offices", which could be based at an institution with high research activity and output. Such an office could thus have pooled tools and/or scarce skilled professionals that can be accessed by other institutions with low research activity and output, through a dedicated innovation champion at such institutions. This role would initially be to regularly interact with researchers and be a central point of contact at such institutions; and in the medium to long term, such innovation champions could then help establish dedicated offices at their institutions. Based on the present research outputs as measured by publications and patents, we are of the view that for at least a few years, there appears to be no compelling reason for establishing fully fledged offices of technology transfer at each and every institution. At present, there may not be justification for more than 10 of these offices to service all the higher-education institutions. We recommend that the initial focus should be to strengthen the capacity of the existing offices to enhance their current skills, expertise and outputs and increase their relevance in the eyes of the researchers and also to establish at least three regional offices to provide pooled resources and skills for the fledgling institutions.

Technology transfer requires patience. It is a particularly new field for most South African higher-education institutions that by and large have tended to focus on other technology transfer mechanisms such as publications and contract research. The process can take anything from three years from the filing of a provisional patent application for the patent to be developed into a commercial product or service which can provide tangible value and benefits before an income stream can be generated. Tamai asserts that technology transfer is similar to the whiskey business, in that it does not yield profits at the early stages - "[whiskey] manufacturer must wait for a long period of time from distillation until introducing properly-aged whiskey into the market". This is the message that should be communicated not only to policy makers but also senior administrators at the institutions, so that undue pressure is not placed on the technology transfer professionals, based on unrealistic monetary expectations, resulting in the latter focusing only on low hanging fruit. As set out in Wolson (2007), technology transfer should be acknowledged as a public good which facilitates the transfer of useful technologies to the marketplace, thereby contributing to economic growth.

Needless to say, a review of the costs incurred by institutions in obtaining patent protection and the revenues generated from commercialization of the patents (see Figures 4 and 5), clearly shows that in general, whereas costs of patenting have increased, the revenues have not followed. What has to be determined beyond the monetary benefits of technology transfer are the secondary benefits of patenting and technology transfer, such as training and human resource development, skills transfer to the industry, development and support of local industries, institutional infrastructure development, improved institution-industry relations and development of technologies that have local and national benefit or contribute toward poverty alleviation. This paper has not examined or measured those secondary benefits, which could be the object of further studies.

The R&D strategy identified a need to prioritize the IP agenda and in particular, a need for: (i) a dedicated fund to finance the securing of IPRs resulting from publicly funded research and development, when this is in the national interest and (ii) a more effective regime for intellectual property derived from publicly funded research.

As this paper has demonstrated, the low rate of protection of research outputs at the institutions, particularly those of higher education, which form a single unit of dedicated workers employed to generate knowledge, has persisted.

4.5. Policy Initiatives and Impact on IP Management and Commercialization

In order to incentivize institutions to protect their knowledge, in 2004, the DST, through its instrument the Innovation Fund,[22] set up a Patent Support Fund to provide wholesale subsidies for patenting costs incurred by the institutions and also a Patent Incentive Fund to provide monetary incentives to researchers at the institutions to protect their knowledge which has the potential for commercialization. In order to benefit from this Fund, the institutions must have an IP policy which includes benefit-sharing arrangements for inventors.

In light of the requirements of the Patent Support Fund for institutions together with the IPR Framework Policy (DST, 2006) and the impending legislation (IPR-PFRD Bill, 2008), institutions without IP policies have started to develop policies consistent with the provisions of the IPR Framework Policy and impending legislation. This legislation requires institutions to establish a designated office of technology transfer to undertake institutional obligations.

In recognition of the lack of capacity in the area of IP management in the publicly financed institutions, the Innovation Fund has set up a patent attorney development program aimed at addressing the racial imbalance within the South African IP system whilst at the same time contributing to human resource development for enhanced IP management and commercialization. There are currently four candidates in the program, with a further 10 expected to be recruited before the end of 2009. In 2005, a program to enhance commercialization skills within the public sector, run by the Innovation Fund together with Deloitte Innovations, a private-sector consulting firm, delivered seven candidates out of the 10 participants. The Innovation Fund will, during the course of 2008, launch a new commercialization manager-development program (CHUMA) to develop commercialization skills for public sector institutions.

The various policy initiatives, largely driven by the DST and its instruments, have played and will continue to play an important role in the institutions' contribution to South Africa's economic growth.

5. CONCLUSIONS

Although South African publicly financed institutions are generally characterized by low patenting activity coupled with low conversion of these patents to licenses and/or products, a majority of the major higher-education institutions and at least two of the science councils have made significant progress toward laying a sound foundation for IP management and technology transfer. As patenting activity is dependent on research activity and research output, not all higher-education institutions will have high patenting activity as, according to the DoE, not all higher-education institutions are meant to be research intensive, with some geared toward teaching. This is also explicit in R&D expenditure per higher-education institution. There is a need, as set out in the Ten-Year Plan for Science and Technology (DST, 2007), to increase the development of research capacity at the institutions if South Africa is to progress to a knowledge economy.

This paper has also shown that although there are low patenting rates, most patenting activity at the institutions has a bias toward biomedical/biotechnology and ICT with some important exceptions (e.g. patents by Mintek). There is some noticeable citation of patents emanating from the institutions, with a few of them forming part of licensed patent portfolios, indicating their relevance and importance within the sectors in which they are filed.

We could not find evidence of patenting affecting publication rates in respect of the most prolific inventors. Instead, they indicated that a focus on patenting tended initially to impose delays in publication as they became acquainted with the patenting process.

In general, preliminary evidence was found of a relationship between research expenditure and output as measured by publication and patenting activity, with a few anomalies which have been attributed to policy inadequacies and also institutional focus.

The institutions have had variable success in commercializing their patents. Spin-off formation is not a significant activity or preferred mode of commercialization by most of them. At least half of the spin-off companies and also revenues generated by most of the institutions were not based on patents but other forms of intellectual property.

The institutional arrangements in respect of managing and commercialization of intellectual property are at an early stage, with a shortage of skilled professionals posing a challenge to the protection and commercialization of research results. The lack of harmonized IP policies with clear benefit-sharing arrangements for inventors has also contributed to the low rate of patenting by the institutions. Technology transfer activities should be viewed as a public good aimed at ensuring that publicly financed intellectual property or technologies developed at the institutions reach the marketplace where they can be utilized for the greater benefit of society.

The various initiatives by the DST and the Innovation Fund to support IP management and commercialization, which require institutions to develop clear institutional policies, are consistent with the impending legislation (IPR-PFRD Bill, 2008). This legislation provides clear guidelines on the development of such institutional policies and required institutional arrangements for IP management and commercialization. These initiatives are indicative of the support of the South African government in the establishment of a knowledge-driven economy that can contribute to the country's growth, poverty alleviation and competitiveness. The ultimate goal of these initiatives should be: (i) the promotion of intellectual property; (ii) greater protection for intellectual property by the institutions; (iii) increased commercialization of intellectual property by the institutions; (iv) improvement in general awareness of IP issues by researchers; and (v) promotion of IP management and commercialization-related human resources for the benefit of South Africa's National System of Innovation. The support and cooperation of the various stakeholders, namely the researchers, the institutions, the government and industry, is vital to the realization of these goals, which should ultimately result in more technologies developed at the institutions making their way to the market place. We are of the view that the promotion of intellectual property together with the improvement of public awareness of IP issues should result in researchers paying more attention to protecting their research results thereby increasing patenting activity. The development of appropriate human resources for IP management and commercialization coupled with the increased focus on commercialization of intellectual property, whether for economic or public good, should result in improved quality of patenting and higher conversion of patents to licenses and/or products and services.

As the present work has shown, it is important that there is a balanced approach to IP management, not just patenting, and to effect such a balanced approach requires skilled professionals to provide the required advice. The South African government's Ten-Year Plan for Science and Technology (DST, 2007) acknowledges that, in order to progress toward a knowledge-based economy, South Africa needs to "increase the number of patents and products, and in order to do that, some investment should be made in increasing the number and type of skills in engineering, technology and economic interface (the innovation skills)". The Plan further states that focus should be on four elements: (i) human capital development; (ii) knowledge generation and exploitation; (iii) knowledge infrastructure; and (iv) enablers to address the innovation chasm between research results and socio-economic outcomes. These elements are consistent with the goals articulated above. In order to achieve them, there should be increased targeted funding for the institutions, aimed not only at research in high priority technology areas that will contribute to economic growth, poverty alleviation and ensuring that South Africa competes globally with its peers, but also for the development of critical human resources to undertake such research and optimally manage and commercialize the intellectual property emanating from such research.

Notes

1 Available at *http://en.wikipedia.org/wiki/List_of_universities_in_South_Africa#Current_Official_South_African_Universities*

2 Available at *http://www.wes.org.wenr/04 May/feature.html*

3 As used in this paper, start-up refers both to spin-off companies on which an institution has an equity position and also those companies established on the basis of the institution's intellectual property by its researchers and/or other parties where the institution has no equity position.

4 Available at *http://www.wipo.int/patentscope/en/*

5 Available at *http://www.micropatent.com*

6 On the possible limitations of patent citations as an indicator of economic and technological relevance see: Hall *et al*. (2005)

7 Available at *http://www.csir.co.za*

8 Available at *http://www.arc.agric.za*

9 Available at *http://www.wrc.org.za*

10 Available at *http://www.mintek.co.za*

11 Available at *http://www.mrc.co.za*

12 The 2007 data is incomplete and is not representative of all the applications filed during 2007, as the 141 patent applications are based on publication and the patent applications filed toward the end of 2007 would not have been published by December 31, 2007 (the cut-off date for the review period).

13 It is important to note that the most recent applications have a lower likelihood of being cited by subsequent applications. In particular, applications made in 2007 and part of 2006, would not have received any citations, as any applications that may have cited them would not have been published by December 2007.

14 While the document count adds up to 25, the total number of patents is 23 due to more than one applicant cited in certain documents.

15 See Chapter 2 by Wynberg *et al*. for more information on this patent and other CSIR patents relating to this product.

16 At the time of writing, 1 rand was equivalent to approximately US$0.12.

17 As will be discussed below, revenues from licensing may not be the primary reason for institutions to engage in patenting and licensing, and, as a result, may also have limitations as a measure of success. However, the figures provide interesting information on the economics of technology transfer at South African research institutions.

18 Available at *http://www.innovationfund.ac.za*. The Innovation Fund is an instrument of the Department of Science and Technology managed by the National Research Foundation. It was established to promote cross-sectorial collaborative research and fund end-stage research and commercialization of South African intellectual property.

19 Available at *http://www.universityworldnews.com/article.php?story=20071108145540742* (South Africa: universities set priorities for research), November 11, 2007.

20 Telephonic interview with Rudi van der Walt, Director of Innovation and Head of TTO (North West University) on July 11, 2008.

21 The Department of Science and Technology announced on January 14, 2009, that the Intellectual Property Rights Bill had been signed into law

22 The Innovation Fund is an instrument of the DST managed by the National Research Foundation. It was established to promote cross-sectorial collaborative research and fund end-stage research and commercialization of South African intellectual property.

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