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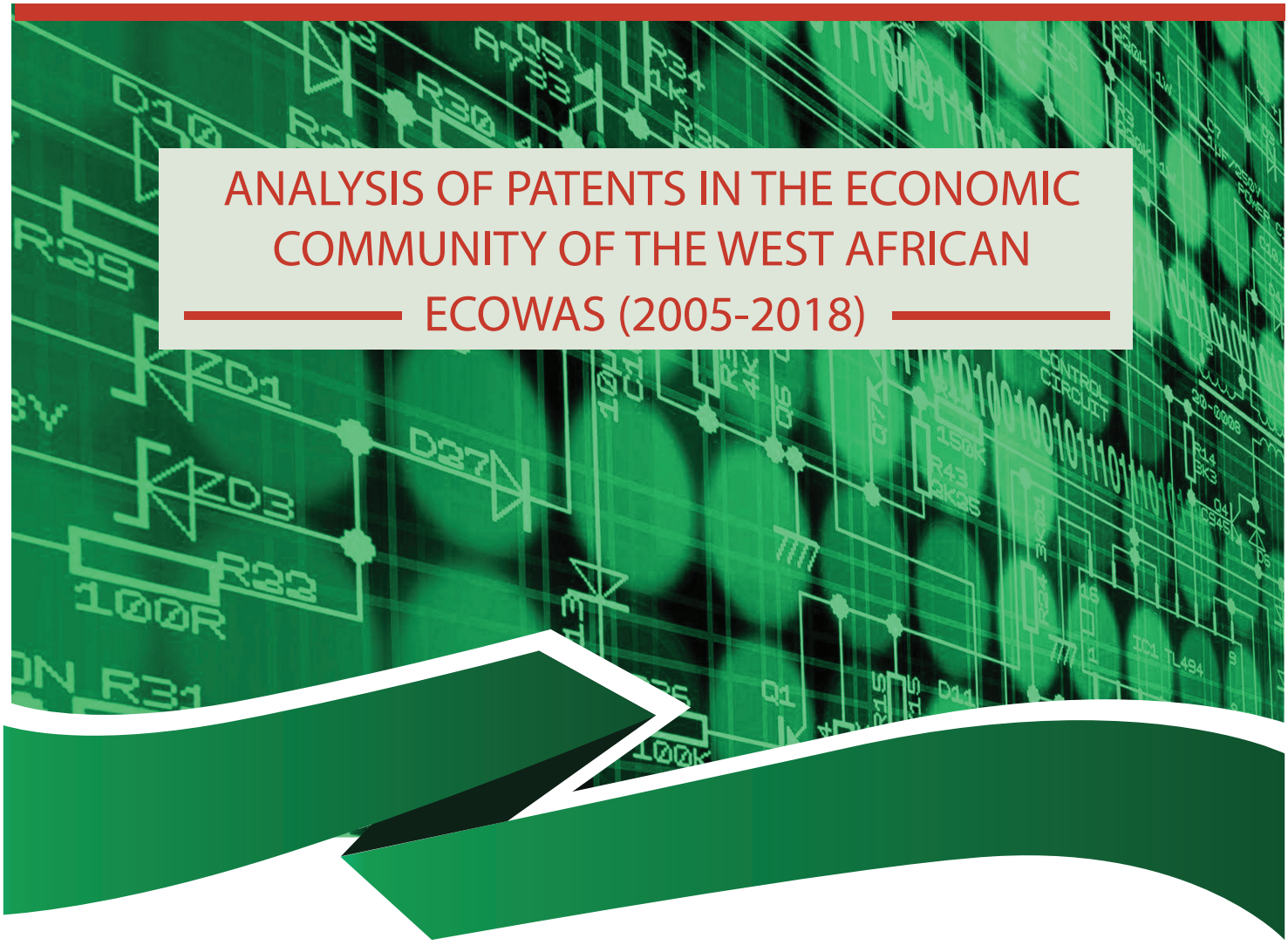

ANALYSIS OF PATENTS IN THE ECONOMIC COMMUNITY OF THE WEST AFRICAN ECOWAS (2005-2018)

ECOWAS Innovation Outlook
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4. Acronyms

AMU	Arab Maghreb Union
AOSTI	African Observatory of Science, Technology and Innovation
ARIPO	African Regional Intellectual Property Organisation
ECOPOST	ECOWAS Policy on Science, Technology and Innovation
ECOWAS	Economic Community of the West African States
EPO	European Patent Office
GI	Growth Index
GII	Global Innovation Index
GR	Growth Ratio
HDI	Human Development Index
IP	Intellectual Property
ICR	International Collaboration Rate
INPADOC	International Patent Documentation
IPR	Intellectual Property Rights
JPA	Japan Patent Office
RECs	Regional Economic Communities
OAPI	Organisation Africaine de la Propriété Intellectuelle
PAIPO	Pan-African Intellectual Property Organisation
PCT	Patent Cooperation Treaty
OTDAV	Tunisian Organism for the Protection of Copyrights and Related Rights
SI	Specialisation Index
STI	Science, Technology and Innovation
STISA-2024	Science, Technology and Innovation Strategy for Africa 2024

5. Acknowledgements

Words from the project leads

This study which presents the innovation profile of ECOWAS and outlines the strengths and weaknesses of the region in patenting activities is the fruit of the collaboration between the ECOWAS Commission and the African Union Commission in science, technology and innovation (STI). This collaboration aims inter alia to provide STI indicators necessary for evidence-based decision making for sustainable development in the ECOWAS. The data necessary for the production of the indicators provided by this study were compiled and analysed from WIPO data and the PATSTAT database (Spring 2019 Edition) in collaboration with Science-Metrix Inc., Montreal, Canada. The project leads thank the ECOWAS Commission for funding the project, the African Observatory of Science, Technology and Innovation (AOSTI) of the African Union Commission for the design and the execution of the study the member States of the ECOWAS for their various inputs, colleagues at AOSTI and at the Science & Technology Division of ECOWAS for their support, and all those who contributed to the successful implementation of the project.

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Message of the Director Education, Science & Culture, ECOWAS Commission

The ECOWAS Education, Science and Culture Department welcomes the presentation of the report on the analysis of patents in the ECOWAS region as an indirect indicator for measuring innovation. This report is the fruit of the partnership between ECOWAS and the African Observatory on Science, Technology and Innovation (AOSTI), an institution of the African Union. This report which presents a mapping of patent applications by ECOWAS, their growth and their comparison with other regions of Africa and the world was developed and executed under the supervision of Dr Vroh Bi Irié, Project Coordinator at AOSTI in collaboration with Dr Roland KOUAKOU, Head of Science and Technology Division in the Education, Science and Culture Department of ECOWAS.

The ECOWAS Education, Science and Culture Department would like to take this opportunity to thank in particular, HE Dr Jean Claude Kassi BROU (President of the ECOWAS Commission), Professor Leopoldo AMADO (ECOWAS Commissioner in charge of Education, Science and Culture), HE Professor Sarah Ayang Agbo (Commissioner of Human Resources, Science and Technology of the African Union Commission), Dr Mahama Ouédraogo (Director, Human Resources, Science and Technology of the Union Commission African) for having accepted and supported the realization of the project. I would also like to thank all the staff of the Education, Science and Culture department of ECOWAS as well as that of AOSTI whose contributions were highly appreciated.

Prof. Abdoulaye MAGA
Director Education, Science & Culture
ECOWAS Commission

Message from the ECOWAS Commission Education, Science and Culture Commissioner

I am pleased to present the first report on the Analysis of Technometric Indicators of ECOWAS Patents for the period 2005 - 2018 on the innovation perspective of ECOWAS. It is the result of a collaboration between the ECOWAS Commission and the African Union Commission through its African Observatory on Science, Technology and Innovation (AOSTI). This report is part of the ECOWAS Program on the Information System on Science, Technology, Engineering and Mathematics (STEM) in West Africa whose objective is to provide information on STEM in the region. The report shows the importance of patents used to characterize the innovation performance of a country, a region and companies in terms of new technologies, new processes or new products.

It establishes the weaknesses of African countries and most of the ECOWAS member countries which do not have a national office directly granting patents. ECOWAS countries are members of regional patent protection organizations and are also signatories to international agreements for the protection of intellectual property rights, which allows them to file patent applications in Africa and outside of Africa. The analysis of technometric indicators questions the role of national, regional and international patent offices in obtaining a satisfactory estimate of patent production at national and regional levels.

This report supports the ECOWAS Policy on Science, Technology and Innovation (ECOPOST), the ECOWAS Strategic Framework (CSC 2016-2020), the African Union Strategy on Science, Technology and Innovation (STISA-2024), the Continental Strategy for Education in Africa (CESA 16-25) with the perspective of achieving the 2020 vision of ECOWAS and the objectives of Agenda 2063 of the African Union and the Sustainable Development Goals (SDG 2030).

Prof. Leopoldo AMADO
Education, Science and Culture Commissioner
ECOWAS Commission

6. Executive Summary

Science, technology and innovation (STI) can provide answers to development bottlenecks in general and provide solutions particularly for the achievement of the Sustainable Development Goals (SDGs) and the African Union Agenda 2063. This applies to the development vision of the ECOWAS where the region has specifically adopted a policy on science, technology and innovation called ECOPOST and in which the development and the management of STI indicators constitute the main objectives of the axis 9. The present study on patenting activities of the region fits therefore in that axis of the ECOPOST and the ECOWAS vision 2020. The analysis of patents is often used as a proxy for measuring innovation activities, since patents are a formal protection for innovative progress. As such, patents can be used to characterise the innovation performance of countries, regions and companies in terms of new technologies, new processes or new products. A number of analyses have established statistically significant relationships between patent counts and innovation. Indeed, patents are incentives to innovation by conferring exclusive rights and high returns on investments to innovators in regions where the contextual factors (including policies) are favourable.

Like the majority of African countries, most ECOWAS member countries do not have national offices delivering patent directly; they are members of regional patent organisations and signatories of international agreements for the protection of intellectual property rights, which allows them to file patents within and outside Africa. Therefore, the analysis of technometric indicators for African countries must interrogate national, regional and international patent offices for a satisfactory estimate of national and regional outputs. This report summarises the findings from the analysis of patents in the Economic Community of the West African States (ECOWAS). For comparison purposes, the patenting profile of the regional economic community of the Arab Maghreb Union (UMA) is summarized for the same period (2005-2018), and an overview of patenting activities in Africa and in the World is given. The Study allowed to cross check and to analyse patent applications and patent grants from major databases and patent offices.
The major findings of the study are:

1. Innovation activities as measured by patent applications are low in Africa. Africa's share was less than 1% of the world total patent applications in 2016, and Africa's effort represented only 0.6% of the global patent grants of 2016. Asia and North America combined have more than 80% share of World total patent grants in 2016;
2. Given the fragmentary nature of African patenting data sets, technometric studies employing a mixed team approach centered around collaborations with national and regional offices in Africa is necessary to capture patent data and indicators for the continent;
3. The study shows that more than 65% of the ECOWAS patent applications are filed abroad, meaning the ECOWAS file patents mostly in foreign patent offices;
4. Among the countries analysed, Algerian, Moroccan and Tunisian inventors appeared to have the most sustained propensity to patent, and their countries held the highest patent counts in the USPTO, EPO and data sets from the triadic families. Each of these countries has a national office or institute for the protection of intellectual property rights (IPRs) delivering patents;
5. International collaboration rates were very high among the set of the ECOWAS granted patents. For instance, international collaboration represents 84% and 82% of patents granted to ECOWAS in the European Patent Office (EPO) and in the US Patent and Trademark Office (USPTO), respectively. In comparison, the world average level of international collaboration for patent grants stood at 7% in USPTO;

6 International collaborations are commonly perceived as conducive to innovation. However, such a high international collaboration rate needs further investigations, as it may indicate:

- A lack of critical mass and infrastructure in the innovation domain investigated;
- Activities of transfer of innovation and expertise towards the ECOWAS;
- An "invention drain" away from the ECOWAS, as the region is not yet putting in use most of these patents for its industrialisation.

For these purposes, the analysis of 600 triadic patent families (USPTO, EPO, JPO and some national offices) showed that the top five countries with the most co-inventions with the ECOWAS and the AMU countries are the United States (USA), France, China, Germany and India. The likelihood of these partners using the collaborative patents for their own needs is very high.

7 The specialization index from patent grants revealed that, out of the 35 WIPO technological fields analysed, the ECOWAS region is focused on the "analysis of biological materials", "pharmaceuticals", "biotechnology", "organic fine chemistry" "food chemistry", "basic material chemistry", "chemical engineering" "environmental technology", "digital communication", and "materials, metallurgy";

8 In the USPTO, the field of "computer technology" account for the highest number of patents granted to the ECOWAS but the region stands at 11% below the world average focus in that field;

9 Overall, the study shows that ECOWAS, like Africa as a whole, needs to step up its efforts to catch up with the rest of the world in innovative activities and IP protection as measured by patents;

10 Building and operationalising national patent offices in the ECOWAS and strengthening the collaboration with existing regional patent offices such as OAPI (Organisation Africaine de la Propriété Intellectuelle) and ARIPO (African Regional Intellectual Property Organisation) would increase the proximity of innovators to patent offices, enhance patenting activities and facilitate the collection and the analysis of patents data in the ECOWAS.

11 The study showed that for the analysed period, with the exception of South Africa in ARIPO, the two regional patent offices in Africa (ARIPO and OAPI) are more used by foreign countries than by Africans themselves. At ARIPO, the top five users by order and number of patents granted are United States, South Africa, United Kingdom, France and Germany, and the top five users of OAPI by order are United States, France, United Kingdom, Germany and the Netherlands. These levels of innovation activity of foreign countries can be explained by the fact that these countries seek to protect their innovations on the African market. More detailed studies are needed to know the nature of these foreign innovations protected on the African market;

12 Despite the importance of patents, global statistics on patents and technologies show that most of the significant innovations have never been patented; Thus, for innovation policy needs, ECOWAS can draw lessons from the following facts:

- As this study shows, the number of patents granted to ECOWAS is significantly lower than the world average and the averages of some regions of Africa;
- Patenting costs, patent maintenance fees, and the cost of patent litigation in courts are relatively high, which means that most ECOWAS innovators may not have the necessary financial means to submit, maintain, defend and protect their innovations;
- Globally, a significant number of granted patents never enter the production market for various reasons, including abandonment by the innovator or owner (for example, failure to pay the annual maintenance fees of patents).

Therefore, while ECOWAS is gearing up to increase its capacity for patent production and use, the region must also explore alternatives to traditional patents, such as utility models, trade secret, “first on the market advantages", and Protected Geographical Indication (PGI).

The frameworks and decisions to improve the implementation of these options include:

- Strengthening existing policies and creating new policies to support innovators for patent processing;
- Promoting policies that encourage the use of alternatives to classical patents. This would include: legislation on interest rates, tax rates, subsidies, minimum price and wages;
- Creating national and regional offices of valorisation of innovation and most importantly operationalising these offices;
- Supporting for start-ups and SMEs (small and medium-sized enterprises) that manufacture and/or commercialise innovative products from the ECOWAS (promotion of the "Made in" ECOWAS), including protected geographical indication products from the ECOWAS;
- Establishing and/or improving regulations on foreign consumer goods import that may unfairly compete with innovative products of the same types made in the ECOWAS;
- Promoting policies to boost the industrial production and commercialization of the “made in” ECOWAS;

7. Introduction

Innovation is the foundation of competitiveness and one of the key drivers of economic growth, social well-being and environmental adaptation. Encouraging innovation is part of the Sustainable Development Goals (SDGs) and the aspirations of the African Union Agenda 2063. Awareness for innovation-driven development has indeed increased considerably through different frameworks aimed at creating an environment conducive to innovation. The aspirations of the African Union Agenda 2063 call for a revolution in education and skills based on science, technology and innovation for a knowledge economy. Specifically, the AU STI Strategy for Africa 2024 (STISA-2024) and its slogan "On the wings of innovation" clearly indicate the emphasis on innovation in Agenda 2063 to sustainably support development in Africa. Among its priorities, the African Union Commission is pursuing the strengthening and the creation of institutions dedicated to the protection of intellectual property rights. The policy on science, technology and innovation (ECOPOST) of the Economic Community of the West African States (ECOWAS) puts also a great emphasis on innovation, in line with several other regional and continental frameworks for the sustainable development of ECOWAS.

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs, and symbols, names and images used in commerce. Specific laws protect these aspects of IP. Intellectual property protection is not yet fully developed in Africa, where only a few countries have national offices delivering patents. In the context of broader efforts to foster and promote innovation, the African Union Commission intends to strengthen and create institutions for the protection of intellectual property rights (IPR). The protection of IP is not yet fully developed in Africa, where only a few countries have national patent offices. To address this lacuna, regional patent offices have been established, such as the African Regional Intellectual Property Organization (ARIPO) and the Organisation Africaine de la Propriété Intellectuelle (OAPI).

Furthermore, in January 2016, the African Union adopted the statute of a single Pan-African Intellectual Property Organization (PAIPO) as the result of a long-term collaboration with the regional economic communities, the world intellectual property organization (WIPO), ARIPO and OAPI. Although PAIPO is still in the making, it underlines the desire of African countries to promote a development-oriented intellectual property system. Worldwide, the major patent offices include the United States patent and trademark office (USPTO), the European patent office (EPO) and the Japan patent office (JPO), the three of which host also the triadic patent family to support the same inventions in countries where they are registered. Beside these major patent offices, many countries possess national patent offices or file patent to regional offices where they hold memberships.

Technometrics is often seen as a proxy for measuring innovation activities, since patents are a formal protection for new technological progress, which is more and more often built upon formal research. Previous analyses have established statistically significant relationships between patent counts and innovation (Acs et al. 2002). Thus, patents can be used to characterise the innovation performance of companies and countries in terms of new technologies, new processes or new products. These indicators are also useful for the analysis of critical aspects of national innovation systems, particularly in terms of creativity, and the protection and the use of intellectual properties. An exploratory technometric study (patent analysis) conducted by the African Observatory of Science, Technology and Innovation (AOSTI) showed that African innovators submit patent applications to both African and international patent offices. Using the databases of these patent offices makes it possible to analyse the outputs of African countries using specific technometric indicators for measuring patent submissions, patents granted and the impact of patents.

The successful use of innovation for development depends on contextual factors such as the general health of the economy, governance, education, science and technology system, infrastructure, etc. Measuring innovation is therefore complex because of these dimensions. Thus, indicators related to patents and R&D expenditure are commonly used as proxies of innovation, with quality adjustment and normalisations.

The creation of the African observatory of science, technology and innovation (AOSTI) to measure STI in Africa and to support evidence-based policymaking is another proof of the resolve of Africa to use STI to accelerate its development. A previous collaboration effort between the ECOWAS Secretariat and the African Union Commission through AOSTI produced the bibliometrics profile of the region, which highlighted details on the scientific production, the scientific field of specialisation and aspects of R&D collaboration for the ECOWAS (ECOWAS, 2017). Also, an exploratory technometric study (patent analysis) conducted by AOSTI showed that African innovators submit patent applications to African patent offices as well as to the aforementioned international patent offices. Using the databases of these patent offices allow the analysis the outputs of African countries in terms of patent applications, patent registration, patent grants, and impact of patents through specific technometric indicators.

The first part of the report gives an overview of Africa and ECOWAS for patent applications and patents grants from the WIPO database. The second part of the report uses specific indicators including specialization index to analyse in details patent activities in the ECOWAS. For comparison purposes, the patent activities of the 5 member States of the Arab Maghreb Union (AMU) were analysed for the same period.

8. Innovation and human development indexes in the ECOWAS and the AMU

The Global Innovation Index (GII) assessments appear to offer the best current coverage of IPR practices for the AMU and ECOWAS regions, even if findings remain partial and subject to important limitations. According to the 2018 edition of the GII rankings, the 15-member States of the ECOWAS rank in the bottom 26 countries of the world in terms of innovation. Senegal has the best ranking in the ECOWAS for the two years of ranking (2016 & 2017) and has also the best position in the output sub-index. A new cut off rules threshold that requires the availability of 66% of indicators in each of the sub-indices left some countries out of the ranking for specific years; Thus, Ghana and Cape Verde which were among the biggest achievers in innovation in previous years of the GII ranking, and a number of African countries were left out in the 2018 edition, underlying the necessity for Africa to scale up its STI data collection and analysis efforts.

The 2018 edition of the assessment notably found Senegal to be within the top three most innovative countries of its country income group. The 2018 edition also marked the entry of Tunisia in the select group of 20 "Innovation achievers", defined as "countries that outperform on innovation relative to their level of development." Morocco benchmarked in third position of African countries in the 2016 edition of the GII. The Moroccan Office of Industrial and Commercial Property attributes this strong posting to policies targeting industrial development and the updating of IPR provisions, translating into particularly good scores for applications in geographical indications as well as industrial design applications. Morocco is also home to a vigorous software industry that would likely make sustained use of the local patent registration system. In the 2018 edition of the report, Morocco positioned itself among the top 10 most innovative nations of its country income group. Conversely, Algeria, Benin, Burkina Faso, Ghana and Togo were all identified in the 2018 edition of the GII as displaying performances below the levels expected when considering their respective GDP levels.

The 2018 Edition of the Human Development Index (HDI) ranking of countries shows that ECOWAS needs to ramp up its efforts to raise the living conditions of its population. Cabo Verde has the best position of the region at 125th on 189 countries ranked, and Ghana comes second in the region at the 140th position. The remaining 13 ECOWAS member Sates rank among the last 29 countries of the world in terms of Human Development.

The ranking for the ECOWAS shows that the region must adopt a broad approach to review its innovation systems at the national and regional levels. Indeed, ranking country for the GII input sub-index takes into account institutions, governance, human capital and research, infrastructure, market sophistication and business sophistication, while the GII output sub-index which includes scientific production through publications and patents takes into account knowledge and technology output, and creative output. The HDI is a composite statistic combining indicators of life expectancy, education, and income per capita.

Therefore, the GII and HDI rankings as shown in the Table 1 call for urgent actions to address the challenges facing the region and to use the opportunities in order to improve the well-being of the population. Such undertakings can be linked to the science, technology and innovation policy of the ECOWAS (ECOPOST), the African Union's STI Strategy (STISA-2024), and to specific programmes such as to the current works ongoing on the analysis of national innovation systems (NIS) at the African Observatory of Science, Technology and Innovation (AOSTI) which include the analysis of NIS of a number of ECOWAS countries.

Table 1. Global innovation Index (GII) and Human Development Index (HDI), 2018

	Global ranking 2018			
Countries	**GII 2018****	**GII Input Sub-index 2018 rang**	**GII Output Sub-index 2018 rang**	**Human Dev. Index (HDI) 2018*****
Benin	121	110	123	163
Burkina Faso	124	117	125	183
Cabo Verde	-	-	-	125
Cote d'Ivoire	123	122	121	170
Gambia	-	-	-	174
Ghana	107	108	102	140
Guinea	119	124	118	175
Guinea Bissau	-	-	-	177
Liberia	-	-	-	181
Mali	112	118	100	182
Niger	122	113	122	189
Nigeria	118	116	115	157
Senegal	100	102	90	164
Sierra Leone	-	-	-	184
Togo	125	125	124	165

Notes: **GII 2018: 126 countries ranked. *** HDI 2018: 189 countries ranked.

Sources: Cornell University, INSEAD, and WIPO (2018); UNDP (2018).

9. Methods and indicators

The indicators and patent offices used to analyse patent activities are described below:

- Number of patent applications were subdivided into:
  - Resident patents: A resident filing refers to an application filed in the country by its own resident;
  - Non-resident patents: A non-resident filing refers to an application filed by a foreign applicant;
  - Abroad: Means patent applications filed by a country's resident at a foreign office.
- Number of patents granted

9.1 Patent counts

Full and fractional counting are the two principal ways of counting the number of patents originating from a given country, organisation or any other entity. The current study presents findings obtained through full counting. Both methods are presented below for reference.

In the full counting method, each patent is counted once for each entity listed in the address field (either for inventors or applicants depending on the statistic being prepared). For example, if two inventors from Nigeria and one from Morocco were awarded a patent, the patent would be counted once for Nigeria and once for Morocco. The same method applies for applicants. When it comes to groups of institutions (e.g., research consortia) or countries (e.g., ECOWAS), double counting is avoided. This means that if inventors from Liberia and Togo are co-awarded a patent, when counting patents for the ECOWAS this patent will be credited only once, even though each country will have been credited with one patent count at the country level.

Fractional counting is used to ensure that a single patent is not counted several times. This approach avoids the use of total numbers across entities (e.g., inventors, organisations, regions, countries) that add up to more than the total number of patents, as is the case with full counting. Ideally, each inventor/applicant on a patent should be attributed a fraction of the patent that corresponds to his or her level of participation in the invention process compared to the other inventors/applicants. Unfortunately, no reliable means exists for calculating the relative effort of inventors/applicants on a patent, and thus each is granted the same fraction of the patent.

Given the level of output measured for ECOWAS and AMU member states, a decision was made to use full counting because fractional counting can become counterintuitive when dealing with low numbers (e.g., a score of 0.25 patents is not really indicative and can be the result of a single patent with inventors from four countries, or two patents each involving eight countries).

9.2 Patent families

Triadic patents consist of a series of patents with at least one filing in each of the three following countries (offices): Europe (the EPO), the US (the USPTO) and Japan (the Japan Patent Office [JPO]). They correspond to the same invention and the same applicant or inventor. A patent family is a series of patent applications related to the same or to similar technical content. The applications of a patent family are linked to each other through priority claims. Two types of patent families are used in this report. The first type is DOCDB patent families, which creates patent families of patents sharing the exact same priorities. From these, we identified triadic families (i.e., those with at least an application at the USPTO, EPO and JPO) to prepare statistics on triadic patents.

The second type of families is International Patent Documentation (INPADOC) families. Patents in an INPADOC family all share at least one priority with another patent in the family, but they do not have to meet the obligation of sharing exactly the same priority with all other members. This results in larger families that connect various parts of a single invention together. In this study, INPADOC patent families were used to prepare statistics based on a larger number of patent offices because we rely on inventorship information within INPADOC patent families to fill gaps in inventorship information for specific offices for which data are not always available. By using multiple approaches to fill gaps in inventorship information, mostly using data from other patent offices in INPADOC patent families, we were able to retrieve most of the missing information, with a relatively high level of precision. This approach enables the production of statistics across most patent offices, providing more insight into where AMU and ECOWAS member states applied for patents at the world level.

9.3 Applications versus granted patents

All the statistics discussed in the report were based on granted patents, except for triadic family, INPADOC family and OTDAV counts, for which only applications are presented. Application data for the USPTO, EPO, ARIPO and OAPI are available in the companion databook to the report. One important distinction between patent applications and patent grants is the considerable time lag between the two. An application is made closer to the time of invention, whereas the granted patent is awarded closer to the commercial return of the invention. Useful and complementary statistics can be derived from both approaches. However, as listed below, several limitations in the quality of data on applications reduce their potential for the development of indicators.

- Applicants can ask that the application not be published. Currently, only about 70% of patent applications are published. This proportion varies by type of industry, Patent Cooperation Treaty (PCT) versus non-PCT, size of company, country and over time. Importantly, once patents are granted, unpublished applications become public; this subsequently adds to the existing number of applications, which were made public at the moment of application. Therefore, the exact number of applications for a given year is not known until at least 7–8 years later because of the time lapse between application and grant. These results have at least two implications: (1) statistics are always incomplete in more recent years, and (2) because of the variability in application-to-grant time, statistics for the most recent years are biased.

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- Trends displayed for applications, while close to reality, do not perfectly reflect it. Several applications do not have any information on the country and/or the state and/or the applicant name and/or the US class. This information is sparse, and the quality varies from one provider to another. Therefore, while relevant information can be extracted from statistics on patent applications, it is important to remember these limitations when looking at the data. Application data for the EPO, while not hindered by the same limitations as those at the USPTO, are still not perfectly aligned with official statistics from the EPO (only about 90% of the patent applications reported by the EPO are available in PATSTAT). One hypothesis for this is that patent applications at the EPO can be retracted before reaching publication, which means that these will not be published and therefore not be available in PATSTAT, but they are still counted by the EPO as applications. Further investigation would be needed to confirm this hypothesis though.

9.4 Growth ratio, growth index and trends

The growth ratio (GR) measures the rate at which a given entity's production changed from one period of time to another. For example, an entity's GR for the 2009–2016 period is calculated by dividing its cumulative output from 2013 to 2016 by its cumulative output from 2009 to 2012. A GR of 1 indicates no change, a GR above 1 indicates growth, and a GR below 1 indicates decreased production. Because the GR is a single number that does not communicate information on the yearly fluctuations within a trend, output trend data for each entity are also included as a bar graph in the results tables.

An entity's growth index (GI) is simply its GR in a given area relative to a reference entity's GR in that area (e.g., the world, a country). That is to say, the GR of a country divided by the GR of the world gives the GI of that country; for example, if a country has increased production by 32% (country's GR = 1.32) in a given area, and the global output in that area has increased by 10% (world GR = 1.10), then the country's production has been growing 20% faster than that of the world (country's GI = 1.20).

In the present study, because data gaps varied depending of the patent office at stake, GRs were measured using different periods. These variations are easily identified in the results tables because the two periods used for the computations of the GRs and GIs are displayed alongside the global period of the study for each patent office.

9.5 International collaboration

International collaboration is defined as any patent co-invented by at least two countries. The international collaboration rate (ICR) of a country is simply a measure of how many patents are co-invented with international partners as a proportion of the given country's total patent output.

9.6 Specialisation index

The specialisation index (SI) indicates how much emphasis a given entity (e.g. country) puts on one field, relative to the reference (African or global) average of effort exerted in that field. For instance, if 20% of a given country's patents are in optics, but at the global level only 15% of patents are in optics, then the country is said to be specialised in optics, putting more emphasis on that field than is normally the case elsewhere around the world.

The SI reference value is 1; accordingly, an SI above 1 shows that an entity invests proportionately more effort than the global average in a given area, an SI below 1 shows that an entity invests proportionately less effort than the average in that area, and an SI near 1 shows that an entity invests close to the average proportion of effort in that area. It is worth noting that the SI is a zero-sum game, as it is measured as a proportion of total output. If the proportion of an entity's output in one area increases, there must be relative decreases elsewhere.

Because of the low numbers of patents presented in this study for ECOWAS and AMU member states, the SIs, although displayed in the tables, are not highly informative for most countries as they can be volatile when based on a handful of patents. Caution is advised when analysing these; readers should rely more on patent counts to assess the involvement of countries in technological areas.

10. Overview of patent applications by Africa and ECOWAS

In Africa the protection of intellectual property remains to be fully developed. A few African countries have national patent systems and offices. To fill the void and to create critical mass at patent offices, regional patent offices such as ARIPO, with 19-member states (mostly anglophone) and countries that have observer status at ARIPO such as Nigeria, and OAPI composed of 17 francophone countries were created (Table 2). Most ECOWAS member countries do not have national patent offices and are members of regional patent offices (ARIPO or OAPI).

Despite the presence of these regional offices, the ECOWAS countries file patents to the international patent offices because they are members of several international patent agreements (Table 2). For instance, apart from Cape Verde (Cabo Verde) all other ECOWAS countries are party to international agreements on the protection of intellectual property rights such as the Patent Cooperation Treaty (PCT) which allows them to file international patent applications in a large number of countries according to the guidelines of the PCT, and the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organization (WTO-TRIPS).

Table 2. Status of ECOWAS in regional patent offices and IP protection agreements

Countries	OAPI	ARIPO	PCT	WTO-TRIPS
Benin	X		X	X
Burkina Faso	X		X	X
Cabo Verde				X
Cote d'Ivoire	X		X	X
Gambia		X	X	X
Ghana		X	X	X
Guinea	X		X	X
Guinea Bissau	X		X	X
Liberia		X	X	X
Mali	X		X	X
Niger	X		X	X
Nigeria*			X	X
Senegal	X		X	X
Sierra Leone		X	X	X
Togo	X		X	X

Note: *Nigeria has Observer Status at ARIPO

Sources: ARIPO, OAPI, WIPO (2018).

10.1 Contribution of Africa to the global patent applications

The analysis of patent applications by origin presented in Figure 1 shows that Africa is the continent that contributes the least to the global stock of patent applications. Apart from Egypt and South Africa that are located among the medium to high rate applicants, the remaining African countries are among the lowest, with a number of African and ECOWAS countries without data.

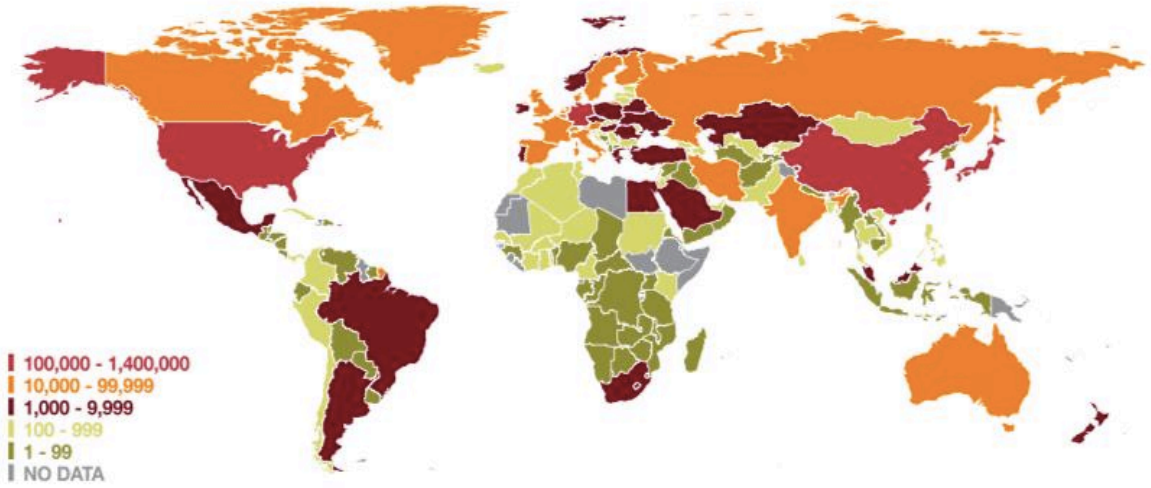

Figure 1. Patent applications by origin 2016

Source: WIPO data 2017

The 2006 and 2016 data (Figure 2) show that Asia and North America are the world leaders in patent applications. Both regions combined have filed more than 75% of the global patent applications in 2006, and 85% in 2016. In the same time span, Africa's share was less than 1% of the world total patent applications, with an average growth rate (2006-2016) of 3.3 %.

The analysis of patent grants indicates that only 0.6% of the global patent grants of 2016 are from Africa, with a 2006-2016 growth rate of 5.7% (WIPO 2017). Asia and North America combined have more than 80% share of World total patent grants in 2016, with an average growth rate (2006 – 2016) of 7.7% for Asia and 5.7% for North America.

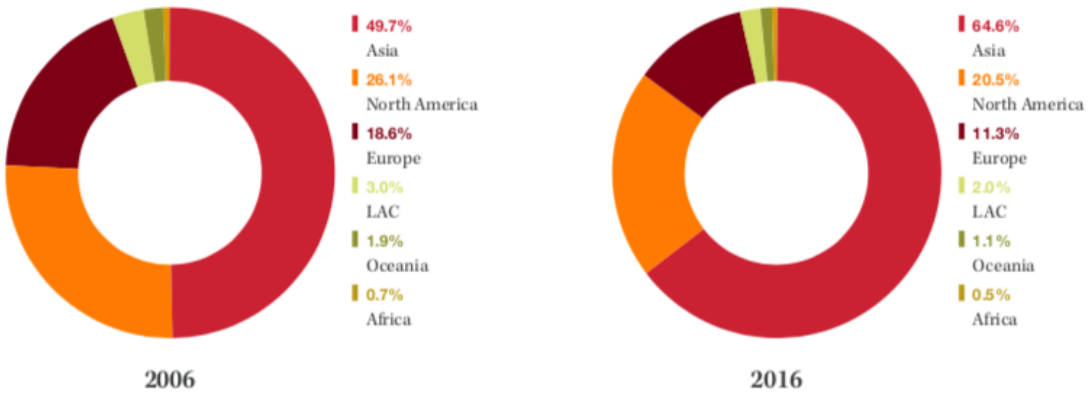

Figure 2. Patent applications by region

Source: WIPO data 2017

10.2 Patent applications by the ECOWAS (2006-2016)

The number of patents owned by an institution or a country can be considered an indicator of the intensity of innovative activities. Among several other technometric indicators, patent application provides a timelier and more direct indicator of inventive activities of the entity (company, country, region, etc.) of interest.

The analysis showed that the numbers of patent applications and patents grants from the ECOWAS are lower than the numbers of patent applications and patent grants from Morocco alone, and slightly higher than the same numbers from Tunisia. When the top two productive countries of Africa in terms of patents applications and patents grants, namely South Africa and Egypt are considered relative to the ECOWAS for the 10 years under study (2006-2016), the numbers of patents applications from South Africa and from Egypt taken individually are significantly higher than the numbers from the ECOWAS, respectively.

The analysis of patents can provide useful information for policy analysis and interventions. Figure 2 refers to a subdivision of patent applications into 3 types defined below:

- **Resident patents: A resident filing refers to an application filed in the country by its own resident**
- **Non-resident patents: A non-resident filing refers to an application filed by a foreign applicant**
- **Abroad: Means patent applications filed by a country's resident at a foreign office.**

The analysis of the 3 types of patents applications (Figure 3) shows that more than 65% of the ECOWAS patent applications are filed abroad. Most ECOWAS countries are signatories of various international treaties on intellectual property rights protection and can therefore use that opportunity to file patents abroad in several international patent offices.

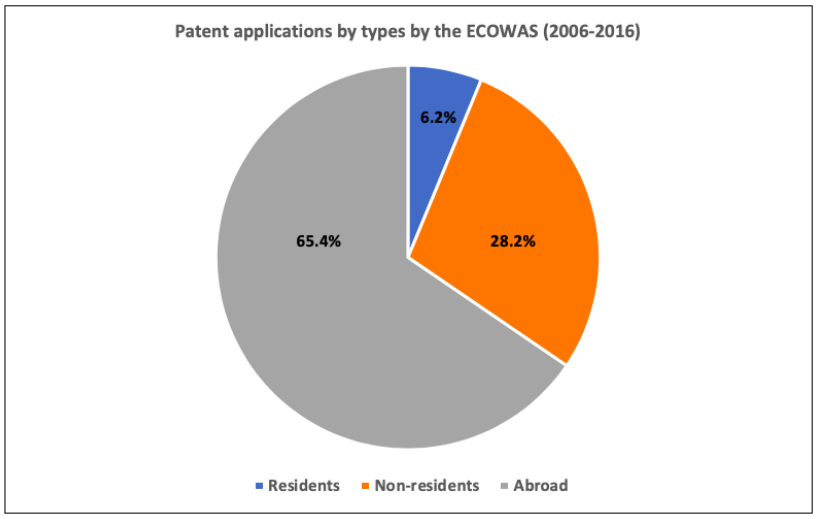

Figure 3. Patent applications by types for the ECOWAS (2006-2016)

Source: Computed from WIPO data 2017

At the country level, the contribution of "filing abroad" to the total number of patent applications is 7.4 % for Nigeria and 41.7% for the Gambia. For the remaining ECOWAS countries, it varies from 92.4% in Cote d'Ivoire to 100% in Cabo Verde, Liberia and Sierra Leone. The latter three countries have the lowest number of patent applications in the ECOWAS (Figure 4)

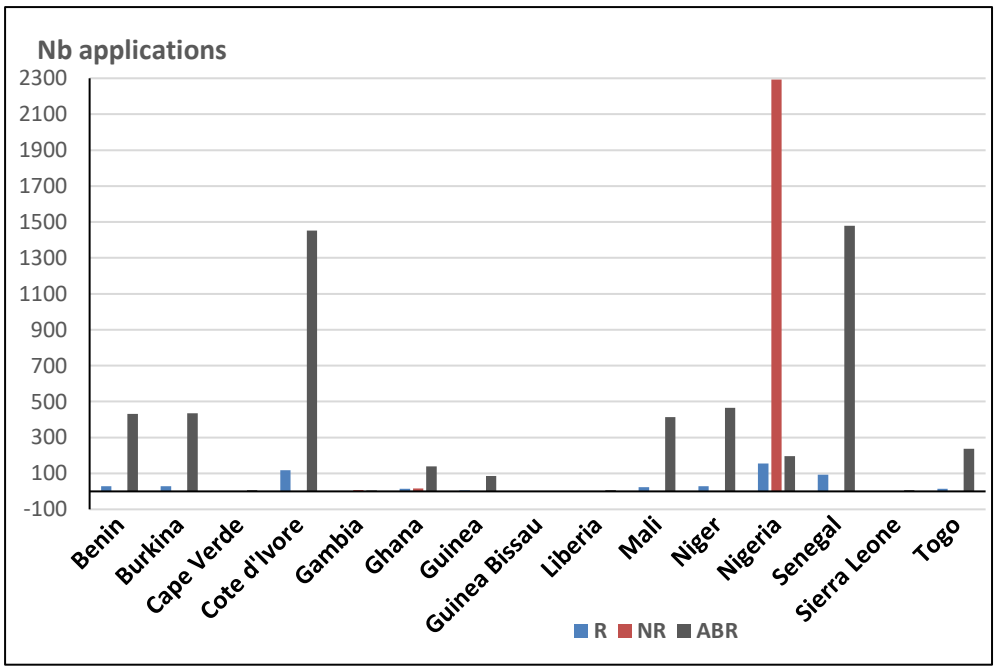

Figure 4. Patent applications by Residents (R), Non-Residents (NR) and Abroad (ABR) from ECOWAS countries (2006-2016)

Source: Computed from WIPO data 2017

The examination of the 3 types of patent applications at the ECOWAS country level shows that the majority of the ECOWAS country, overwhelmingly file patent abroad (Table 3), with the exception of the Gambia and Nigeria which in turn have relatively high numbers of applications by Non-residents (foreign applications). In the case of Nigeria, 86,6% of the applications are foreign applications. A possible explanation of the high share of foreign applications in these countries may be that the first applicants in the list of authors are registering with foreign residence addresses, although they may be Gambian or Nigerian nationals, or that filing patents through Nigeria and Gambia offers some advantages to foreign applicants. Also, it should be noted that in explaining the high share of non-resident applications, the possibility or foreigners working in Nigeria and Gambia (but having foreign addresses) on patentable issues is not excluded here.

Table 3. Distribution of patent applications by residents, non-residents and abroad for ECOWAS countries, ARIPO and OAPI (2006-2016)

Countries/Patent office	% Resident	% Non-resident	% Abroad
Benin	6.3	0	93.6
Burkina	6.2	0	93.7
Cape Verde	0	0	100
Cote d'Ivoire	7.5	0	92.4
Gambia	0	58.3	41.6
Ghana	8.1	9.9	81.8
Guinea	5.5	0	94.4
Guinea Bissau	0	0	0
Liberia	0	0	100
Mali	5.2	0	94.1
Niger	5.8	0	94.1
Nigeria	5.8	86.6	7.4
Senegal	5.9	0	94
Sierra Leone	0	0	100
Togo	5.9	0	94
ARIPO*	2.4	97.6	-
OAPI*	27.3	72.7	-

Note: Computed from WIPO data; *Share (%) for ARIPO and OAPI computed for the year 2016 only.

10.3 Patent grants versus patent applications in the ECOWAS

In technometrics when the intention is to measure intellectual property (IP), it is preferable to measure patents granted rather than patent applications. Table 4 shows the proportion of patent grants in ECOWAS countries relative to the volume of patent applications. This is further detailed in Figure 5 which compares the shares of patent applications and patent grants. Out of all the applications filed by the ECOWAS as a whole, an average of 24,5% were grants in the 2006-2016 period.

Table 4. Patent grants as percent patent applications by ECOWAS countries (2006-2016)

Countries	% patent grants
Benin	31.7
Burkina	27
Cabo Verde	11.1
Cote d'Ivoire	36.9
Gambia	0
Ghana	26.8
Guinea	44.8
Guinea Bissau	0
Liberia	36.4
Mali	24.7
Niger	14.9
Nigeria	40.3
Senegal	29.3
Sierra Leone	11.1
Togo	33.3

Note: Computed from WIPO data 2017

The distribution shows (Figure 5) that the ECOWAS member States compared to each other and are currently at varied levels of success in terms of IP protection.

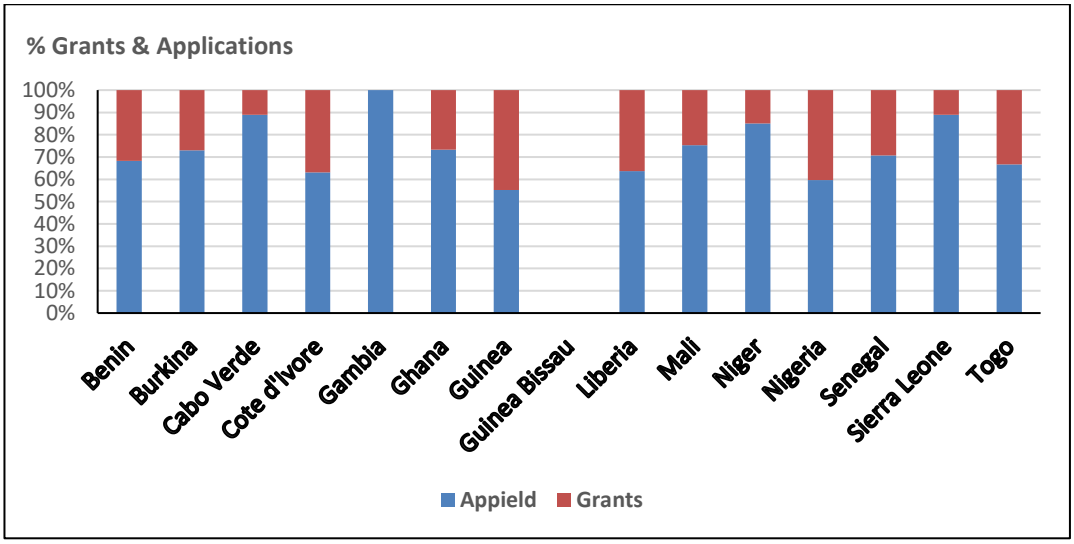

Figure 5. Distribution of patent examination outcomes for ECOWAS countries

Source: Computed from WIPO data 2017

In technometrics when the intention is to measure intellectual property (IP), it is preferable to measure patents granted rather than patent applications. Table 4 shows the proportion of patent grants in ECOWAS countries relative to the volume of patent applications. This is further detailed in Figure 5 which compares the shares of patent applications and patent grants. Out of all the applications filed by the ECOWAS as a whole, an average of 24,5% were grants in the 2006-2016 period.

11. Patent analysis

The findings presented below will focus on granted patents rather than patent applications, given that data are more robust in recent years for the first category. Nevertheless, results from the analysis of triadic patent families and International Patent Documentation (INPADOC) families and from the Tunisian national office's database are based on patent applications only, either because of the intrinsic nature of the indicator (i.e., triadic and INPADOC patent families) or because the grant status of patents is not available.

Tables included in this report are for granted patents, except for entities or categories for which only application data are available. Table 5 is an example of patent grants based on the World Intellectual Property Organization technology classification. Application data for the USPTO, the EPO and the ARIPO are available in the companion databook file. It should be noted that roughly equivalent patents may be included in data sets from different patent offices. The analysis of triadic patent families presented in section 11.6 controls for this effect, although it simultaneously filters out other subgroups of patents as well.

Table 5. Distribution of patent grants across WIPO technological fields for ECOWAS and AMU Member States (2005–2018)

Country/Region	Office	PATSTAT	Analysis of biological materials	Audio-visual technology	Basic communication processes	Basic materials chemistry	Biotechnology
World	EP	997,358	20,935	47,679	15,631	47,335	48,625
	US	3,303,823	49,987	322,428	104,093	105,779	127,146
	Triadic	538,703	19,440	51,805	11,814	47,493	40,674
AMU	EP	146	8	2	1	11	22
	US	181	3	8	8	20	25
	Triadic	385	11	38	11	45	32
ECOWAS	EP	32	2	1	0	4	3
	US	153	8	14	5	8	13
	Triadic	192	8	9	2	26	22
AMU							
Algeria	EP	18	2	0	0	1	1
	US	23	0	0	0	3	1
	Triadic	99	2	14	2	13	4
Libya	EP	1	0	0	0	0	0
	US	4	0	0	0	1	0
	Triadic	11	1	0	1	0	1
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	0	1	1	0	0
Morocco	EP	69	4	2	0	8	10
	US	85	1	6	4	9	10
	Triadic	124	8	6	1	23	19
Tunisia	EP	58	2	0	1	2	11
	US	69	2	2	4	7	14
	Triadic	122	0	17	6	10	8
ECOWAS							
Benin	EP	1	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	3	0	0	0	0	0
Burkina Faso	EP	2	0	0	0	0	0

Country/Region	Office	PATSTAT	Analysis of biological materials	Audio-visual technology	Basic communication processes	Basic materials chemistry	Biotechnology
	US	5	0	0	0	0	1
	Triadic	4	0	0	0	2	0
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	1	0	1	0	0	0
Gambia	EP	2	1	0	0	0	2
	US	4	0	0	0	3	2
	Triadic	2	1	0	0	0	1
Ghana	EP	5	0	0	0	1	0
	US	16	0	1	0	2	1
	Triadic	47	0	1	0	6	3
Guinea	EP	3	0	0	0	0	0
	US	3	0	0	0	0	0
	Triadic	4	0	0	0	0	0
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	0	0	0	1	0
	US	1	0	0	0	0	0
	Triadic	10	0	0	0	1	0
Liberia	EP	1	0	0	0	0	0
	US	4	0	1	0	0	0
	Triadic	2	0	1	0	0	0
Mali	EP	1	0	0	0	1	0
	US	19	1	3	1	2	1
	Triadic	4	1	0	0	1	1
Niger	EP	0	0	0	0	0	0
	US	39	1	6	2	0	3
	Triadic	21	2	2	0	2	6
Nigeria	EP	4	0	1	0	0	0
	US	38	6	0	1	1	4
	Triadic	72	3	4	1	12	10
Senegal	EP	7	1	0	0	1	1
	US	7	0	0	0	0	1

Country/Region	Office	PATSTAT	Analysis of biological materials	Audio-visual technology	Basic communication processes	Basic materials chemistry	Biotechnology
	Triadic	10	1	0	0	2	1
Sierra Leone	EP	1	0	0	0	0	0
	US	13	0	3	1	0	0
	Triadic	9	0	0	0	0	1
Togo	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	4	0	0	1	0	0

Country/Region	Office	PATSTAT	Chemical engineering	Civil engineering	Computer technology	Control	Digital communication
World	EP	997,358	44,740	41,200	65,704	26,883	79,146
	US	3,303,823	116,909	103,596	730,585	139,536	344,996
	Triadic	538,703	39,653	11,872	78,167	23,186	52,603
AMU	EP	146	11	4	3	1	13
	US	181	15	11	26	12	24
	Triadic	385	18	2	65	6	66
ECOWAS	EP	32	1	1	2	0	3
	US	153	9	7	30	7	20
	Triadic	192	17	4	22	3	34
AMU							
Algeria	EP	18	0	1	0	0	1
	US	23	2	1	1	1	2
	Triadic	99	4	0	10	1	23
Libya	EP	1	0	0	0	0	0
	US	4	1	1	0	0	0
	Triadic	11	1	0	1	0	1
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	1	0	29	0	1
Morocco	EP	69	7	2	0	0	6
	US	85	9	0	15	6	12
	Triadic	124	6	0	10	3	21
Tunisia	EP	58	4	1	3	1	6
	US	69	3	9	10	5	10

Country/Region	Office	PATSTAT	Chemical engineering	Civil engineering	Computer technology	Control	Digital communication
	Triadic	122	6	2	15	2	21
ECOWAS							
Benin	EP	1	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	3	0	0	0	0	2
Burkina Faso	EP	2	0	0	0	0	0
	US	5	0	0	1	0	0
	Triadic	4	0	0	0	0	2
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	2	0	1
	Triadic	1	0	0	0	0	0
Gambia	EP	2	0	0	0	0	0
	US	4	0	0	1	0	0
	Triadic	2	0	0	0	0	0
Ghana	EP	5	0	0	0	0	1
	US	16	1	0	2	0	4
	Triadic	47	6	0	6	0	5
Guinea	EP	3	0	0	2	0	1
	US	3	1	0	0	0	0
	Triadic	4	2	0	0	0	0
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	0	0	0	0	0
	US	1	1	0	0	0	0
	Triadic	10	2	0	1	1	0
Liberia	EP	1	0	0	0	0	0
	US	4	0	0	1	0	0
	Triadic	2	0	0	1	0	0
Mali	EP	1	0	0	0	0	0
	US	19	1	2	3	2	2
	Triadic	4	1	0	1	0	0
Niger	EP	0	0	0	0	0	0
	US	39	0	0	11	1	11
	Triadic	21	0	0	2	0	1

Country/Region	Office	PATSTAT	Chemical engineering	Civil engineering	Computer technology	Control	Digital communication
Nigeria	EP	4	0	1	0	0	0
	US	38	3	4	3	2	2
	Triadic	72	6	1	11	2	21
Senegal	EP	7	1	0	0	0	1
	US	7	0	0	2	0	0
	Triadic	10	0	0	0	0	0
Sierra Leone	EP	1	0	0	0	0	0
	US	13	1	1	4	2	0
	Triadic	9	0	3	0	0	0
Togo	EP	0	0	0	0	0	0
	US	2	1	0	1	0	0
	Triadic	4	0	0	0	0	3

Country/Region	Office	PATSTAT	Electrical machinery, apparatus, energy	Engines, pumps, turbines	Environmental technology	Food chemistry	Furniture, games
World	EP	997,358	89,648	51,971	21,688	15,371	27,115
	US	3,303,823	320,114	110,921	54,947	33,414	106,678
	Triadic	538,703	74,725	31,411	16,530	10,113	13,136
AMU	EP	146	12	2	8	7	0
	US	181	14	3	10	9	1
	Triadic	385	57	6	11	13	6
ECOWAS	EP	32	3	0	0	4	1
	US	153	8	2	4	3	3
	Triadic	192	14	5	3	7	4
AMU							
Algeria	EP	18	2	1	1	2	0
	US	23	3	0	4	1	0
	Triadic	99	18	2	4	1	4
Libya	EP	1	0	0	0	0	0
	US	4	0	0	0	0	0

Country/Region	Office	PATSTAT	Electrical machinery, apparatus, energy	Engines, pumps, turbines	Environmental technology	Food chemistry	Furniture, games
	Triadic	11	0	0	0	0	0
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	0	1	1	0	0
Morocco	EP	69	5	0	3	0	0
	US	85	6	2	4	3	1
	Triadic	124	10	1	3	5	0
Tunisia	EP	58	5	1	4	5	0
	US	69	5	1	2	5	0
	Triadic	122	29	2	3	7	2
ECOWAS							
Benin	EP	1	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	3	0	0	0	0	0
Burkina Faso	EP	2	0	0	0	0	0
	US	5	0	0	0	0	1
	Triadic	4	0	0	0	0	0
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	1	0	0	0	0	0
Gambia	EP	2	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	2	0	0	0	0	1
Ghana	EP	5	0	0	0	1	0
	US	16	1	0	1	0	0
	Triadic	47	3	0	2	4	0
Guinea	EP	3	0	0	0	0	0
	US	3	0	0	0	0	0
	Triadic	4	0	1	0	0	1
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	0	0	0	0	0

Country/Region	Office	PATSTAT	Electrical machinery, apparatus, energy	Engines, pumps, turbines	Environmental technology	Food chemistry	Furniture, games
	US	1	0	0	0	0	0
	Triadic	10	2	0	0	0	0
Liberia	EP	1	1	0	0	0	0
	US	4	1	0	0	0	0
	Triadic	2	0	0	0	0	0
Mali	EP	1	0	0	0	0	0
	US	19	3	0	0	0	0
	Triadic	4	0	0	0	0	0
Niger	EP	0	0	0	0	0	0
	US	39	1	1	1	0	0
	Triadic	21	1	1	0	0	0
Nigeria	EP	4	0	0	0	2	0
	US	38	0	1	0	3	1
	Triadic	72	7	2	1	2	1
Senegal	EP	7	2	0	0	1	1
	US	7	1	0	0	0	0
	Triadic	10	1	0	0	0	0
Sierra Leone	EP	1	0	0	0	0	0
	US	13	1	0	1	0	1
	Triadic	9	0	1	0	0	1
Togo	EP	0	0	0	0	0	0
	US	2	0	0	1	0	0
	Triadic	4	0	0	0	1	0

Country/Region	Office	PATSTAT	Handling	IT methods for management	Machine tools	Macromolecular chemistry, polymers	Materials, metallurgy
World	EP	997,358	49,392	4,774	39,702	42,098	30,713
	US	3,303,823	102,971	86,309	100,256	73,149	61,482
	Triadic	538,703	24,372	11,048	26,595	38,212	30,978
AMU	EP	146	1	2	1	6	6
	US	181	4	3	4	9	5
	Triadic	385	6	3	4	44	27
ECOWAS	EP	32	0	0	2	0	1
	US	153	1	5	3	3	2

Country/Region	Office	PATSTAT	Handling	IT methods for management	Machine tools	Macromolecular chemistry, polymers	Materials, metallurgy
	Triadic	192	8	4	2	18	12
AMU							
Algeria	EP	18	0	0	0	1	0
	US	23	1	0	1	2	0
	Triadic	99	1	1	2	22	12
Libya	EP	1	0	0	0	0	0
	US	4	0	0	1	1	0
	Triadic	11	1	0	0	2	0
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	0	0	0	0	1
Morocco	EP	69	0	2	0	5	6
	US	85	1	2	0	4	5
	Triadic	124	1	0	1	16	5
Tunisia	EP	58	1	0	1	0	0
	US	69	2	1	2	2	0
	Triadic	122	3	2	1	4	10
ECOWAS							
Benin	EP	1	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	3	0	0	0	0	0
Burkina Faso	EP	2	0	0	0	0	0
	US	5	0	0	0	0	0
	Triadic	4	1	0	0	0	0
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	1	0	0	0	0	0
Gambia	EP	2	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	2	1	0	0	0	0
Ghana	EP	5	0	0	0	0	1
	US	16	0	0	0	0	1
	Triadic	47	2	1	1	2	5
Guinea	EP	3	0	0	0	0	0

Country/Region	Office	PATSTAT	Handling	IT methods for management	Machine tools	Macromolecular chemistry, polymers	Materials, metallurgy
	US	3	0	0	0	0	1
	Triadic	4	1	0	0	0	1
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	10	0	1	0	2	0
Liberia	EP	1	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	2	0	0	0	0	1
Mali	EP	1	0	0	0	0	0
	US	19	0	0	0	2	0
	Triadic	4	0	0	0	0	0
Niger	EP	0	0	0	0	0	0
	US	39	1	1	1	1	0
	Triadic	21	2	0	1	1	0
Nigeria	EP	4	0	0	0	0	0
	US	38	0	3	1	0	0
	Triadic	72	1	2	0	11	3
Senegal	EP	7	0	0	1	0	0
	US	7	0	0	1	0	0
	Triadic	10	0	0	0	2	1
Sierra Leone	EP	1	0	0	1	0	0
	US	13	0	1	0	0	0
	Triadic	9	0	0	0	0	1
Togo	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	4	0	0	0	0	0

Country/Region	Office	PATSTAT	Measurement	Mechanical elements	Medical technology	Micro-structural and nano-technology	Optics
World	EP	997,358	67,384	58,340	86,374	4,231	38,914
	US	3,303,823	262,594	123,599	226,485	20,313	222,834
	Triadic	538,703	56,377	30,781	64,700	8,611	41,220
AMU	EP	146	6	2	8	1	3
	US	181	16	2	9	1	4
	Triadic	385	23	1	17	15	36
ECOWAS	EP	32	1	3	2	0	0
	US	153	13	3	11	2	6
	Triadic	192	17	7	12	8	16
AMU							
Algeria	EP	18	1	0	3	0	0
	US	23	3	0	3	0	0
	Triadic	99	8	1	5	6	9
Libya	EP	1	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	11	0	0	2	0	0
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	0	0	1	0	0
Morocco	EP	69	2	1	3	1	0
	US	85	9	0	6	1	4
	Triadic	124	10	0	6	4	13
Tunisia	EP	58	3	1	2	0	3
	US	69	4	2	0	0	0
	Triadic	122	6	0	3	6	14
ECOWAS							
Benin	EP	1	0	0	0	0	0
	US	1	0	0	0	0	0
	Triadic	3	0	0	0	0	0
Burkina Faso	EP	2	0	0	0	0	0
	US	5	0	0	1	0	0
	Triadic	4	0	0	0	0	0
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0

Country/Region	Office	PATSTAT	Measurement	Mechanical elements	Medical technology	Micro-structural and nano-technology	Optics
	Triadic	1	1	0	0	1	1
Gambia	EP	2	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	2	1	0	0	0	0
Ghana	EP	5	0	0	1	0	0
	US	16	1	0	0	0	0
	Triadic	47	0	1	2	3	0
Guinea	EP	3	0	0	0	0	0
	US	3	0	0	0	0	0
	Triadic	4	0	0	0	0	0
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	0	2	1	0	0
	US	1	0	0	0	0	0
	Triadic	10	1	0	1	1	2
Liberia	EP	1	0	0	0	0	0
	US	4	0	0	0	0	0
	Triadic	2	0	0	0	0	0
Mali	EP	1	0	0	0	0	0
	US	19	1	0	1	0	1
	Triadic	4	1	0	0	0	0
Niger	EP	0	0	0	0	0	0
	US	39	3	0	2	0	2
	Triadic	21	1	2	3	0	3
Nigeria	EP	4	0	0	0	0	0
	US	38	7	1	4	2	2
	Triadic	72	8	3	5	1	10
Senegal	EP	7	1	1	0	0	0
	US	7	1	0	0	0	0
	Triadic	10	2	0	0	1	0
Sierra Leone	EP	1	0	0	0	0	0
	US	13	0	2	3	0	1
	Triadic	9	1	1	1	1	0

Country/Region	Office	PATSTAT	Measurement	Mechanical elements	Medical technology	Micro-structural and nano-technology	Optics
Togo	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	4	1	0	0	0	0

Country/Region	Office	PATSTAT	Organic fine chemistry	Other consumer goods	Other special machines	Pharmaceuticals	Semiconductors
World	EP	997,358	61,399	31,161	56,170	68,483	32,023
	US	3,303,823	149,503	81,350	123,932	152,699	283,683
	Triadic	538,703	61,191	17,584	40,728	64,775	42,351
AMU	EP	146	29	2	7	33	7
	US	181	31	3	4	30	4
	Triadic	385	82	6	35	84	29
ECOWAS	EP	32	4	0	1	8	0
	US	153	13	3	3	22	8
	Triadic	192	53	4	8	56	23
AMU							
Algeria	EP	18	2	0	1	5	1
	US	23	2	1	0	1	0
	Triadic	99	13	1	20	9	9
Libya	EP	1	0	0	0	0	1
	US	4	1	0	0	1	0
	Triadic	11	5	0	1	6	0
Mauritania	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	32	0	0	1	0	0
Morocco	EP	69	22	0	4	17	2
	US	85	15	1	2	13	2
	Triadic	124	41	3	11	40	11
Tunisia	EP	58	5	2	2	11	3
	US	69	13	1	2	15	2
	Triadic	122	24	2	2	30	10
ECOWAS							
Benin	EP	1	0	0	0	1	0
	US	1	0	0	0	0	0

Country/Region	Office	PATSTAT	Organic fine chemistry	Other consumer goods	Other special machines	Pharmaceuticals	Semiconductors
	Triadic	3	1	0	0	1	0
Burkina Faso	EP	2	1	0	0	2	0
	US	5	2	0	0	2	0
	Triadic	4	1	0	0	1	0
Cape Verde	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	1	0	0	0	0	1
Gambia	EP	2	0	0	0	2	0
	US	4	3	0	0	3	0
	Triadic	2	0	0	0	1	0
Ghana	EP	5	1	0	0	0	0
	US	16	0	0	0	7	0
	Triadic	47	25	1	1	20	4
Guinea	EP	3	0	0	0	1	0
	US	3	0	1	0	2	0
	Triadic	4	1	1	0	2	0
Guinea-Bissau	EP	0	0	0	0	0	0
	US	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0
Ivory Coast	EP	5	1	0	1	1	0
	US	1	0	0	0	1	0
	Triadic	10	2	0	1	4	2
Liberia	EP	1	0	0	0	0	0
	US	4	0	0	0	0	1
	Triadic	2	0	0	0	0	0
Mali	EP	1	0	0	0	1	0
	US	19	1	0	0	0	4
	Triadic	4	3	0	0	2	0
Niger	EP	0	0	0	0	0	0
	US	39	2	0	2	4	1
	Triadic	21	4	2	5	9	3
Nigeria	EP	4	0	0	0	0	0
	US	38	3	2	1	2	0
	Triadic	72	9	0	2	10	9

Country/Region	Office	PATSTAT	Organic fine chemistry	Other consumer goods	Other special machines	Pharmaceuticals	Semiconductors
Senegal	EP	7	1	0	0	0	0
	US	7	1	0	0	1	1
	Triadic	10	5	0	0	3	4
Sierra Leone	EP	1	0	0	0	0	0
	US	13	1	0	0	0	1
	Triadic	9	2	0	0	3	0
Togo	EP	0	0	0	0	0	0
	US	2	0	0	0	0	0
	Triadic	4	0	0	0	1	0

Country/Region	Office	PATSTAT	Surface technology, coating	Tele-communications	Textile and paper machines	Thermal processes and apparatus	Transport	Unclassified
World	EP	997,358	30,650	55,790	37,740	22,457	85,722	48
	US	3,303,823	116,847	281,201	80,414	45,100	179,784	1,444
	Triadic	538,703	43,743	47,687	22,145	13,675	41,701	0
AMU	EP	146	7	8	1	1	2	0
	US	181	10	19	4	0	5	0
	Triadic	385	41	68	4	6	8	0
ECOWAS	EP	32	0	2	1	0	0	0
	US	153	4	14	1	0	5	0
	Triadic	192	14	29	4	2	2	0
AMU								
Algeria	EP	18	2	0	0	0	0	0
	US	23	1	1	1	0	2	0
	Triadic	99	18	20	1	3	4	0
Libya	EP	1	1	0	0	0	0	0
	US	4	0	0	0	0	0	0
	Triadic	11	0	1	0	0	0	0
Mauritania	EP	0	0	0	0	0	0	0
	US	0	0	0	0	0	0	0

Country/Region	Office	PATSTAT	Surface technology, coating	Tele-communications	Textile and paper machines	Thermal processes and apparatus	Transport	Unclassified
	Triadic	32	0	1	0	0	0	0
Morocco	EP	69	1	3	0	0	1	0
	US	85	4	5	1	0	1	0
	Triadic	124	13	14	2	1	3	0
Tunisia	EP	58	3	5	1	1	1	0
	US	69	5	13	2	0	2	0
	Triadic	122	11	33	1	2	1	0
ECOWAS								
Benin	EP	1	0	0	0	0	0	0
	US	1	0	1	0	0	0	0
	Triadic	3	0	1	0	0	0	0
Burkina Faso	EP	2	0	0	0	0	0	0
	US	5	0	0	0	0	0	0
	Triadic	4	0	2	0	0	0	0
Cape Verde	EP	0	0	0	0	0	0	0
	US	2	0	0	0	0	0	0
	Triadic	1	1	0	0	0	0	0
Gambia	EP	2	0	0	0	0	0	0
	US	4	0	0	0	0	0	0
	Triadic	2	0	0	0	0	0	0
Ghana	EP	5	0	1	0	0	0	0
	US	16	0	4	0	0	0	0
	Triadic	47	1	5	1	0	1	0
Guinea	EP	3	0	0	0	0	0	0
	US	3	0	0	0	0	0	0
	Triadic	4	0	0	0	0	0	0
Guinea-Bissau	EP	0	0	0	0	0	0	0
	US	0	0	0	0	0	0	0
	Triadic	0	0	0	0	0	0	0
Ivory Coast	EP	5	0	0	0	0	0	0
	US	1	0	0	0	0	0	0
	Triadic	10	1	0	0	0	0	0
Liberia	EP	1	0	0	0	0	0	0
	US	4	0	0	0	0	0	0

Country/Region	Office	PATSTAT	Surface technology, coating	Tele-communications	Textile and paper machines	Thermal processes and apparatus	Transport	Unclassified
	Triadic	2	0	0	0	1	0	0
Mali	EP	1	0	0	0	0	0	0
	US	19	0	0	0	0	1	0
	Triadic	4	0	0	0	0	0	0
Niger	EP	0	0	0	0	0	0	0
	US	39	2	7	0	0	1	0
	Triadic	21	3	1	1	0	0	0
Nigeria	EP	4	0	0	1	0	0	0
	US	38	0	2	1	0	1	0
	Triadic	72	7	17	2	1	0	0
Senegal	EP	7	0	1	0	0	0	0
	US	7	1	0	0	0	0	0
	Triadic	10	1	1	0	0	0	0
Sierra Leone	EP	1	0	0	0	0	0	0
	US	13	1	0	0	0	2	0
	Triadic	9	0	0	0	0	1	0
Togo	EP	0	0	0	0	0	0	0
	US	2	0	0	0	0	0	0
	Triadic	4	0	2	0	0	0	0

11.1 ECOWAS and AMU patenting activity in the US: findings from the USPTO

The first findings presented in this report are dedicated to the patent activity of AMU and ECOWAS member states in the US market. The analyses summarised below were based on USPTO patent date for both applications (data in companion file) and grants (Table 6), globally and per technology field.

Counts of patents from ECOWAS- and AMU-based inventors and owners were higher in the USPTO (total of 334 granted patents for the full period from 2005 to 2018) than in the EPO (178), the ARIPO (7) and the OAPI (90 over a partial three-year period). Considering patent applications instead, results become available for the Tunisian national IPR office (the Tunisian Organism for the Protection of Copyrights and Related Rights), but results are unavailable for the OAPI. When considering this type of patenting record, USPTO-based figures for ECOWAS- and AMU-based inventors and assignees take second place to applications retrieved from the Tunisian database (635 records in the USPTO between 2005 and 2018, compared to 1,387 in the Tunisian database). ECOWAS and AMU inventors and assignees nevertheless applied to more US patents than they did to EPO (319) and ARIPO (9) patents. Overall, the USPTO appears to be the IPR office with the highest attraction for ECOWAS and AMU innovators, especially considering how patent applications from the Tunisian database are almost exclusively linked to inventors and owners based in Tunisia itself.

Of the more than 3.3 million patents granted by the USPTO between 2005 and 2018, about 180 involved inventors from AMU member states (36 per member state on average), slightly more than for ECOWAS, whose output stood at close to 150 patents granted (10 per member state on average). However, although most member states obtained at least a few patent grants, most of the grants were concentrated in a handful of countries: the two member states with the highest level of output, Morocco (85 patents) and Tunisia (69 patents), together accounted for close to 50% of all patents awarded for AMU and ECOWAS member states, and 85% of all patents awarded to AMU member states. Adding the other leading states, Niger (39 patents), Nigeria (38 patents), Algeria (23 patents) and Mali (19 patents), captures 82% of all patents awarded to member states, leaving only a handful of patents for other countries. Among these, Ghana (16 patents) and Sierra Leone (13 patents) are the only other nations with more than 10 patents over the 14-year period.

Given the relatively low levels of output, it is rather difficult to detect patterns within the data, at least for member states, because yearly trends are often quite volatile, as can be observed in the trend charts in Table 5. For instance, AMU experienced a notable, steady growth between 2005 and 2015, before levels of patent activity lowered in 2016, reflecting country-level patterns for Morocco and Tunisia. Overall, growth ratios for AMU and ECOWAS stood at 2.7 and 2.2, respectively, which is above average growth at the world level (1.7). In other words, growth was 60% higher for AMU than the corresponding trend at the world level (i.e., growth index (GI=1.6), and it was 30% higher for ECOWAS (GI=1.3). At the member state level, the strongest growth ratios were observed for Sierra Leone (12) and Senegal (6), which both had only a single patent during the first half of the period covered in the study, and Algeria (6.7, moving from 3 to 20 patents between periods).

Table 6. Trend in patent grants to ECOWAS and AMU member states at the USPTO, 2005–2018

Country/Region	2005-2018	2005-2011	2012-2018	ICR	GR	GI	Trend
World	**3,303,823**	**1,244,090**	**2,059,733**	**7%**	**1.7**	**1.0**	
AMU	**181**	**49**	**132**	**74%**	**2.7**	**1.6**	
ECOWAS	**153**	**48**	**105**	**82%**	**2.2**	**1.3**	
AMU							
Algeria	23	3	20	87%	6.7	4.0	
Libya	4	1	3	100%	3.0	1.8	
Mauritania	0	0	0	N/C	N/C	N/C	
Morocco	85	27	58	76%	2.1	1.3	
Tunisia	69	18	51	65%	2.8	1.7	
ECOWAS							
Benin	1	1	0	0%	0.0	0.0	
Burkina Faso	5	3	2	80%	0.7	0.4	
Cape Verde	2	0	2	50%	N/C	N/C	
Gambia	4	3	1	100%	0.3	0.2	
Ghana	16	8	8	88%	1.0	0.6	
Guinea	3	0	3	67%	N/C	N/C	
Guinea-Bissau	0	0	0	N/C	N/C	N/C	
Ivory Coast	1	0	1	100%	N/C	N/C	
Liberia	4	1	3	100%	3.0	1.8	
Mali	19	10	9	84%	0.9	0.5	
Niger	39	9	30	79%	3.3	2.0	
Nigeria	38	11	27	82%	2.5	1.5	
Senegal	7	1	6	100%	6.0	3.6	
Sierra Leone	13	1	12	77%	12.0	7.2	
Togo	2	0	2	100%	N/C	N/C	

Note: Patents are counted according to the year they were granted by the patent office. The sum across member states may be higher than the total of the groupings because of co-inventorship. Colour coding for patent counts ranges from white (lowest number) to dark green (highest number), and for growth indexes it ranges from dark red (below world average) to white (on par with world average) to dark green (above world average).
Source: Prepared by Science-Metrix using USPTO data indexed in PATSTAT (Spring 2019 edition)

Overall, growth rates were positive and above world levels (1.7) for a total of 9 AMU-ECOWAS countries, negative and therefore below world level for 5 countries, and could not be computed for the remaining 6 countries. International collaboration rates were very high among the set of AMU-ECOWAS granted patents. The overall share of granted patents with inventors and/or owners with locations in more than one country stood at only 7% in the USPTO, whereas this proportion jumped to 74% for AMU patents and 82% for ECOWAS patents. Spot checks in the data set have shown that these high shares may be explained by concurrent affiliations for single inventors, who may share their work time between a foreign and an African location. These findings provide preliminary signals (ideally to be confirmed through additional case studies or field research) that patenting in AMU and ECOWAS member states may take place as part of highly internationalised networks and practices.

This hypothesis will be supported by additional observations provided below.

Finally, an examination of the specialisation index (SI) findings provides an indication of the technological fields in which USPTO patenting activity originating in AMU-ECOWAS states is concentrated, and those in which it is sparse. However, patent counts for AMU-ECOWAS states, when disaggregated by technological class, are associated with small numbers much more susceptible to bias from volatility. Therefore, these specific findings ought to be interpreted with utmost caution.

AMU patents granted by the USPTO between 2005 and 2018 were relatively concentrated in the area of "basic materials chemistry" (20 patents, SI of 3.45), "biotechnology" (25 patents, SI of 3.59), "food chemistry" (9 patents; SI of 4.92) and "organic fine chemistry" (31 patents, SI of 3.78) and "pharmaceuticals" (30 patents; SI of 3.59). The high SI scores obtained for the fields of food chemistry and basic materials chemistry were specific to USPTO patents and not found in the set of EPO patents. ECOWAS innovators concentrated their patenting activity with the USPTO in the fields of "analysis of biological materials" (8 patents; SI of 3.46); "pharmaceuticals" (22 patents; SI of 3.11); and biotechnology (13 patents; SI of 2.21). While the "computer technology" category accounted for the highest number of patents by ECOWAS innovators (count of 30), this measurement still placed member states at a relative low level of specialisation (SI of 0.89) compared to other countries.

11.2 ECOWAS and AMU patenting activity in Europe: findings from the EPO

Close to a million patents were granted by the EPO between 2005 and 2018 (Table 7). Of those, 146 submissions originated with AMU-based innovators and 32 with ECOWAS-based inventors. Distribution of these EPO granted patents among ECOWAS and AMU countries was even more skewed than in the USPTO database, with submissions from Morocco and Tunisia together accounting for more than 70% of these records. Only one other country, Algeria, held more than 10 granted patents in the full period (with a count of 18).

Overall, the EPO may have lost importance for some AMU-ECOWAS innovators over the last decade. Growth rates were above 1.0 for four countries (Algeria, Nigeria, Tunisia and Senegal), whereas they were below 1.0 for six countries (Benin, Burkina Faso, Gambia, Ivory Coast, Sierra Leone and Morocco—although absolute counts were very low in many cases here, and therefore susceptible to more volatility). They could not be computed for the remaining 10 countries. Senegal's positive growth rate is nonetheless below the world trend (1.3 for the country compared to 1.5 in the database), resulting in GI scores that are above 1.0 for only three countries. In the aggregate, AMU countries had increased EPO patenting (again, measured through granted patents) at very much the same rate as other countries in the database (1.4 versus 1.5), while ECOWAS countries' (GI of 0.8) slight increases in EPO patenting put them behind the global trend. Examining findings for applications rather than granted patents yields much the same picture.

Table 7. Trend in patent grants to ECOWAS and AMU member states at the EPO, 2005-2018

Country/Region	2005-2018	2005-2011	2012-2018	ICR	GR	GI	Trend
World	**997,358**	**402,730**	**594,628**	**8%**	**1.5**	**1.0**	
AMU	**146**	**60**	**86**	**71%**	**1.4**	**1.0**	
ECOWAS	**32**	**15**	**17**	**84%**	**1.1**	**0.8**	
AMU							
Algeria	18	3	15	72%	5.0	3.4	
Libya	1	0	1	100%	N/C	N/C	
Mauritania	0	0	0	N/C	N/C	N/C	
Morocco	69	37	32	74%	0.9	0.6	
Tunisia	58	20	38	66%	1.9	1.3	
ECOWAS							
Benin	1	1	0	0%	0.0	0.0	
Burkina Faso	2	2	0	100%	0.0	0.0	
Cape Verde	0	0	0	N/C	N/C	N/C	
Gambia	2	2	0	100%	0.0	0.0	
Ghana	5	0	5	80%	N/C	N/C	
Guinea	3	0	3	67%	N/C	N/C	
Guinea-Bissau	0	0	0	N/C	N/C	N/C	
Ivory Coast	5	5	0	100%	0.0	0.0	
Liberia	1	0	1	100%	N/C	N/C	
Mali	1	0	1	100%	N/C	N/C	
Niger	0	0	0	N/C	N/C	N/C	
Nigeria	4	1	3	100%	3.0	2.0	
Senegal	7	3	4	71%	1.3	0.9	
Sierra Leone	1	1	0	100%	0.0	0.0	
Togo	0	0	0	N/C	N/C	N/C	

Note: Patents are counted according to the year they were granted by the patent office. The sum across member states may be higher than the total of the groupings because of co-inventorship. Colour coding for patent counts ranges from white (lowest number) to dark green (highest number), and for growth indexes ranges from dark red (below world average) to white (on par with world average) to dark green (above world average).
Source: Prepared by Science-Metrix using EPO data indexed in PATSTAT (Spring 2019 edition)

As was the case in the USPTO, AMU-ECOWAS EPO granted patents are to a large degree the result of international collaborations, traceable once again to a number of inventors with affiliations in both European and African countries. AMU innovators were granted patents written as part of an international collaboration at a rate of 71%, while this figure stood at 84% for their ECOWAS counterparts. The countries with the highest numbers of EPO patents—Morocco, Tunisia and Algeria—also displayed some of the comparatively lower shares of international collaboration rate (ICR) (between 66% and 74%). By contrast, for seven countries with 10 or fewer EPO patents each, the full set of patents were designated as part of international collaborations. Here again, patent analysis findings point towards the interest of additional work to characterise the relations of AMU-ECOWAS innovators with international firms or networks.

Turning to relative specialisation (see companion file for details), AMU innovators' patents granted by the EPO tended to concentrate in the fields of "pharmaceuticals" (33 patents; SI of 3.29); "organic fine chemistry" (29 patents; SI of 3.23); and "biotechnology" (22 patents; SI of 3.09). Patent counts by technological fields for ECOWAS countries were too small to enable robust analysis.

11.3 ECOWAS and AMU patenting activity with the ARIPO

PATSTAT holds records of more than 2,700 patents granted by the ARIPO between 2005 and 2018 (Table 8). Of those, only 7 were submitted by AMU-ECOWAS innovators over the full period considered. The number of applications found was only marginally higher at 9. Given such small numbers, reliable conclusions cannot be obtained on ARIPO patenting practices from AMU-ECOWAS innovators, except to declare that they rarely patent innovations at the ARIPO.

Additional spot checks were performed to determine whether the large portion of ARIPO granted patents not captured by the current analysis originated in other African countries often identified as innovative in innovation scoreboards (i.e., South Africa, Egypt), or whether they were predominantly submitted by non-African inventors instead. Results of these additional checks indicates that US inventors were by far the most frequent inventors involved on ARIPO granted patents (738), distantly followed by South African (233) and British (222) inventors (data not shown). French (219), German (198), Australian (163), Indian (153) and Swiss (100) inventors followed, indicating that most patent activity at the ARIPO, apart from the South African component, comes from countries foreign to Africa seeking protection in the African market, with a strong emphasis from western European countries. The second highest-ranking African country, Kenya (11 patents), only comes in 26th place, behind other European countries as well as Asian (i.e., China, South Korea, Singapore) and South American (i.e., Brazil, Chile) countries.

11.4 ECOWAS and AMU patenting activity with the OAPI

OAPI data in PATSTAT for the study period were only available for the years 2005 to 2007. Based on these limited data, it seems that innovators from ECOWAS countries make strong use of the OAPI office compared to other patent offices, with 82 patents granted there (Table 8). This count was roughly five times that of the equivalent USPTO count over the same period, and even further above the counts recorded in the EPO and ARIPO databases. Claims originating from Senegal (22 granted patents), the Ivory Coast (17) and Benin (15) made up almost two thirds of the total ECOWAS figure. Among the AMU states, Mauritania provided almost all records of granted patents over the restricted period considered (7).

As with the situation at the ARIPO, most patent grants at OAPI involved inventors located outside Africa. US (584 granted patents), French (251), British (188), German (109) and Dutch (104) inventors were awarded the highest numbers of patents at the OAPI (data not shown). Cameroon was the highest-ranking African country with 39 patents, placing the country in 9th position, above the ECOWAS member states' performances mentioned above.

Given the restricted period for which records from the OAPI database were available, growth indicators were not computed. Interestingly, ICR levels for ECOWAS and AMU were much lower than those recorded in the other databases examined so far (13% for AMU and 4% for ECOWAS at OAPI, compared to scores above 70% at the USPTO and EPO). It could be that OAPI records capture a different path to innovation taken by (mostly) ECOWAS innovators than the previously analysed databases. Given the comparatively high number of granted patents from AMU-ECOWAS innovators included in the short period analysed here, securing access to, or novel generation of, more comprehensive time series from this database may be a productive contribution to future patent measurement exercises.

Table 8. Trend in patent grants to ECOWAS and AMU member states at the OAPI, 2005–2007

Country/Region	2005–2007	2008–2011	2012-2018	ICR	GR	GI	Trend
World	**1,620**	**N/A**	**N/A**	**12%**	**N/C**	**N/C**	
AMU	**8**	**N/A**	**N/A**	**13%**	**N/C**	**N/C**	
ECOWAS	**82**	**N/A**	**N/A**	**4%**	**N/C**	**N/C**	
AMU							
Algeria	0	N/A	N/A	N/C	N/C	N/C	
Libya	0	N/A	N/A	N/C	N/C	N/C	
Mauritania	7	N/A	N/A	0%	N/C	N/C	
Morocco	1	N/A	N/A	100%	N/C	N/C	
Tunisia	0	N/A	N/A	N/C	N/C	N/C	
ECOWAS							
Benin	15	N/A	N/A	7%	N/C	N/C	
Burkina Faso	3	N/A	N/A	0%	N/C	N/C	
Cape Verde	0	N/A	N/A	N/C	N/C	N/C	
Gambia	0	N/A	N/A	N/C	N/C	N/C	
Ghana	1	N/A	N/A	100%	N/C	N/C	
Guinea	6	N/A	N/A	0%	N/C	N/C	
Guinea-Bissau	0	N/A	N/A	N/C	N/C	N/C	
Ivory Coast	17	N/A	N/A	6%	N/C	N/C	
Liberia	0	N/A	N/A	N/C	N/C	N/C	
Mali	8	N/A	N/A	0%	N/C	N/C	
Niger	9	N/A	N/A	0%	N/C	N/C	
Nigeria	0	N/A	N/A	N/C	N/C	N/C	
Senegal	22	N/A	N/A	0%	N/C	N/C	
Sierra Leone	0	N/A	N/A	N/C	N/C	N/C	
Togo	1	N/A	N/A	0%	N/C	N/C	

Note: OAPI data are only partially indexed in PATSTAT, thereby limiting the period that can be analysed (https://intellogist.wordpress.com/2013/07/06/do-you-know-your-african-regional-patenting-authorities-part-2-oapi/). Patents are counted according to the year they were granted by the patent office. The sum across member states may be higher than the total of the groupings because of co-inventorship. Colour coding for patent counts ranges from white (lowest number) to dark green (highest number), and for growth indexes ranges from dark red (below world average) to white (on par with world average) to dark green (above world average).
Source: Prepared by Science-Metrix using OAPI data indexed in PATSTAT (Spring 2019 edition)

11.5 ECOWAS and AMU national patent offices' activity: a case study of Tunisia

An examination of patenting practices related to the Tunisian Organism for the Protection of Copyrights and Related Rights (OTDAV) is possible in PATSTAT, and such an investigation reveals a wholly different perspective than those obtained by the analyses conducted so far. In brief, the number of patent applications (granted patents are not recorded in PATSTAT for the OTDAV) from Tunisian innovators is five times above the number of equivalent applications found in the EPO and USPTO together (i.e., 1,369 patent applications at OTDAV (Table 9) versus 279 for USPTO and EPO combined). Additionally, this set of patents displays a very low ICR (1%). Taken together, these findings possibly indicate the existence of either patenting communities or patenting practices in Tunisia that are distinct from those captured through the EPO and USPTO data sets. These findings support the idea that many local innovations within the Tunisian market are not pursued for protection in other markets (at least not through the USPTO and EPO). The OTDAV records contained 6,582 patent applications submitted between 2005 and 2018. Of those, 1,369 (around 20%) made mention of at least one Tunisian inventor or assignee. Other AMU States accounted for 17 further applications, while Niger was the only ECOWAS State with a presence in the data set (2 applications).

Table 9. Trend in published patent applications from ECOWAS and AMU member states at the OTDAV, 2005–2018

Country/Region	2005–2018	2005–2009	2011-2015	ICR	GR	GI	Trend
World	**6,582**	**2,385**	**3,321**	**7%**	**1.4**	**1.0**	
AMU	**1,385**	**388**	**658**	**2%**	**1.7**	**1.2**	
ECOWAS	**2**	**1**	**0**	**50%**	**0.0**	**0.0**	
AMU		0	0		N/C	N/C	
Algeria	3	1	2	33%	2.0	1.4	
Libya	0	0	0	N/C	N/C	N/C	
Mauritania	0	0	0	N/C	N/C	N/C	
Morocco	14	5	6	36%	1.2	0.9	
Tunisia	1,369	382	651	1%	1.7	1.2	
ECOWAS		0	0				
Benin	0	0	0	N/C	N/C	N/C	
Burkina Faso	0	0	0	N/C	N/C	N/C	
Cape Verde	0	0	0	N/C	N/C	N/C	
Gambia	0	0	0	N/C	N/C	N/C	
Ghana	0	0	0	N/C	N/C	N/C	
Guinea	0	0	0	N/C	N/C	N/C	
Guinea-Bissau	0	0	0	N/C	N/C	N/C	
Ivory Coast	0	0	0	N/C	N/C	N/C	
Liberia	0	0	0	N/C	N/C	N/C	
Mali	0	0	0	N/C	N/C	N/C	
Niger	2	1	0	50%	0.0	0.0	
Nigeria	0	0	0	N/C	N/C	N/C	
Senegal	0	0	0	N/C	N/C	N/C	
Sierra Leone	0	0	0	N/C	N/C	N/C	
Togo	0	0	0	N/C	N/C	N/C	

Note: Patents are counted according to the year they were applied for. The sum across member states may be higher than the total of the groupings because of co-inventorship. Data are incomplete after 2015 because of delays between application and the publication of applications by the patent office. Colour coding for patent counts ranges from white (lowest number) to dark green (highest number), and for growth indexes ranges from dark red (below world average) to white (on par with world average) to dark green (above world average).

Source: Prepared by Science-Metrix using OTDAV data indexed in PATSTAT (Spring 2019 edition)

The OTDAV saw a sustained rise in applications moving from the 2005–2009 period to the 2011–2015 period. Patent counts increased from almost 2,400 to more than 3,300 applications, resulting in a growth ratio (GR) of 1.4 across the data set. Tunisian inventors increased their volume of applications with an even more pronounced GR of 1.7.

Even with the high involvement of Tunisian inventors at OTDAV, US inventors still had the highest patent application count, with 1,381 patent applications (data not shown), slightly edging out Tunisia's 1,369 patent applications. France ranked 3rd with 1,029 applications, followed by Germany (698), Switzerland (637), Italy (364), the UK (238), Spain (161) and Japan (137). South Africa was the top-ranking African country with 15 applications (27th), followed by Morocco (14 applications, 28th) and Egypt (10 applications, 30th).

11.6 ECOWAS and AMU contributions to triadic patent families

The measure of triadic patent families makes it possible to capture both major innovation advances that directly lead to further R&D activity and the extension of IPR protection to multiple national markets. It was found that AMU-ECOWAS innovators have participated in the development of more than 570 triadic patent families (Table 10). Each of these families contained at least one patent application with mention of an AMU-ECOWAS inventor. In looking at triadic families, patent applications were analysed rather than granted patents. It should be noted that triadic families may potentially include patents from any national patent office in addition to those from USPTO, EPO and the Japan Patent Office (JPO). Furthermore, those patents submitted with the USPTO, the EPO and the JPO might not make mention of AMU-ECOWAS inventors, even if other patents in the family do. Therefore, findings on triadic families for a given country cannot be directly compared with those findings already reported on USPTO and EPO filings.

AMU innovators contributed patent applications to 385 triadic families between 2005 and 2014. Algeria, Morocco and Tunisia all made strong showings on this dimension (99, 124 and 122 patent applications, respectively). The performances of Libyan and Mauritanian innovators were also noteworthy (11 and 32 triadic families), since these counts contrast with much lower numbers of granted patents found for these states in the other databases examined so far. However, Mauritania's performance is characterised by a jump in applications for the year 2014 (27 applications in that year alone) and might not be repeated over time.

ECOWAS innovators contributed to 192 triadic families. Nigerian and Ghanaian innovators made particularly high numbers of contributions within this group of countries (72 and 47 applications, respectively). Niger, Senegal and the Ivory Coast were the other ECOWAS states with triadic counts equal to or above 10 (21, 10 and 10 applications, respectively). Measurements on this indicator were more often in decline when comparing the 2010–2014 period to the 2005–2009 period, in contrast to relatively stable trends observed at the world level (GR≈1). These decreases resulted in a GR of 0.8 for AMU countries taken together, and 0.9 for ECOWAS member states.

The aggregated trend for the AMU region would be even lower if Mauritania's exceptional situation already mentioned above was considered an outlier and taken out of the analysis. Additionally, the strong performers overall that are Morocco and Tunisia halved their numbers of contributions to triadic families going from the first to the second period (82 to 42 applications and 80 to 42 applications, respectively). In the ECOWAS region, Ghana also saw a halving of contributions to triadic families between the two periods (from 31 to 16 applications). However, Nigeria, the leader on this indicator and in the ECOWAS group of states, saw further consolidation of its performance (increasing patent applications from 33 to 39).

2 Patent applications were used because the definition of triadic families is based on families with applications to the USPTO, EPO and JPO

Table 10. Trend in triadic patent families involving ECOWAS and AMU member states, 2005–2014

Country/Region	2005–2014	2005–2009	2010-2014	ICR	GR	GI	Trend
World	**538,703**	**272,435**	**266,268**	**26%**	**1.0**	**1.0**	
AMU	**385**	**214**	**171**	**97%**	**0.8**	**0.8**	
ECOWAS	**192**	**101**	**91**	**99%**	**0.9**	**0.9**	
AMU	0	0	0				
Algeria	99	45	54	98%	1.2	1.2	
Libya	11	9	2	100%	0.2	0.2	
Mauritania	32	1	31	100%	31.0	31.7	
Morocco	124	82	42	95%	0.5	0.5	
Tunisia	122	80	42	95%	0.5	0.5	
ECOWAS	0	0	0				
Benin	3	2	1	100%	0.5	0.5	
Burkina Faso	4	2	2	100%	1.0	1.0	
Cape Verde	1	1	0	100%	0.0	0.0	
Gambia	2	0	2	100%	N/C	N/C	
Ghana	47	31	16	100%	0.5	0.5	
Guinea	4	2	2	100%	1.0	1.0	
Guinea-Bissau	0	0	0	N/C	N/C	N/C	
Ivory Coast	10	2	8	100%	4.0	4.1	
Liberia	2	2	0	100%	0.0	0.0	
Mali	4	4	0	100%	0.0	0.0	
Niger	21	11	10	100%	0.9	0.9	
Nigeria	72	33	39	97%	1.2	1.2	
Senegal	10	4	6	100%	1.5	1.5	
Sierra Leone	9	5	4	100%	0.8	0.8	
Togo	4	3	1	100%	0.3	0.3	

Note: Triadic patent families are patent families for which an application was filed at the USPTO, EPO and JPO offices. Traditionally, the OECD, which developed this indicator, used patent grants at the USPTO because the USPTO did not publish its applications. USPTO applications have now been available for almost two decades, so the OECD now use patent applications at the USPTO for this metric. Triadic families are counted according to the first priority date in the family. The sum across member states may be higher than the total of the groupings because of co-inventorship. Data are not available after 2014 as it takes a few years for patent families to earn the triadic status because patents need to be applied for in different patent offices. Source: Prepared by Science-Metrix using EPO, JPO and USPTO data indexed in PATSTAT (Spring 2019 edition)

High International Collaboration Rate (ICR) scores (95% or more) across all countries and regions compared to the world level (26%) could indicate that AMU and ECOWAS innovators might not yet have developed complex, international patent portfolios on their own. One hypothesis is that AMU-ECOWAS innovators may make discrete contributions to these portfolios as part of broad collaborative networks or when working for multinational firms. Of the close to 600 triadic families involving as part of broad collaborative networks or when working for multinational firms. Of the close to 600 triadic families involving as part of broad collaborative networks or when working for multinational firms. Of the close to 600 triadic families involving (259 co-sponsored patent families), France (150), China (63), Germany (62) and India (55).

ECOWAS patent applications that belonged to triadic families were relatively concentrated in the technological fields of “microstructural and nanotechnology” (8 patents; SI of 2.61); “pharmaceuticals” (56 patents; SI of 2.43); and “organic fine chemistry” (53 patents; SI of 2.43) (data not shown, see companion workbook). “Micro-structural and nanotechnology” (15 patents; SI of 2.44) and “organic fine chemistry” (82 patents; SI of 1.88) also took top spots among fields in the AMU set of patents in triadic families, although there the highest rankings were completed by the field of “telecommunications” (68 patents; SI of 2.00).

11.7 ECOWAS and AMU contributions to INPADOC patent families

INPADOC patent families are measured differently than triadic patent families as they are broader in scope and are not required to encompass applications from the USPTO, EPO and JPO. Therefore, their use makes it possible to identify the national office where the seed patent was issued or submitted because all patent families are considered in this analysis, not only the triadic ones. By examining AMU-ECOWAS contributions to INPADOC families, it is possible to obtain a broader portrait of AMU-ECOWAS patenting across all the patent offices included in PATSTAT.

As can be observed at Table 11, findings from this analysis clearly show that EPO applications amount to only a small part of European filings by AMU-ECOWAS inventors. Almost 300 patent applications with AMU innovators mentioned as inventors or co-inventors contributed to INPADOC families originating in European national offices in countries otherwise covered by the EPO as well (e.g., 185 at the French office, 53 at the Spanish office, 21 at the German office). By contrast, AMU innovators made only 39 contributions to INPADOC families originating from EPO applications. For ECOWAS innovators, the contrast is just as stark: more than 100 patent applications were part of INPADOC families originating in European national offices (e.g., 42 in Germany, 25 in the UK, 20 in France), compared to only 6 originating from the EPO.

Many AMU inventors contributed to INPADOC families seeded in France, notably inventors from Algeria (22 applications), Morocco (86 applications) and Tunisia (79 applications). Morocco also made sustained filings with the Spanish national office (46 applications). Tunisian innovators made notable numbers of applications with the German and South Korean offices (17 and 14, respectively). On the ECOWAS side, Nigeria's activity at the USPTO is expected from the results previously reported above, but its inventors also made notable numbers of filings with the British (12) and South Korean (8) national offices. Sierra Leone had 37 applications falling within INPADOC families originating in the German national office, the highest patent count recorded for the country in the current exercise. Ghana contributed to 28 INPADOC families, which were distributed more evenly among a number of countries, including a few seeded in China, Finland and Luxembourg.

Table 11. Distribution of INPADOC patent families of ECOWAS and AMU member states across all patent offices covered in PATSTAT (2005–2018)

			AMU					ECOWAS													
Patent Office	AMU	ECOWAS	Algeria	Libya	Mauritania	Morocco	Tunisia	Benin	Burkina Faso	Cape Verde	Gambia	Ghana	Guinea	Guinea-Bissau	Ivory Coast	Liberia	Mali	Niger	Nigeria	Senegal	Sierra Leone	Togo
France	185	20	22	0	0	86	79	1	3	0	0	0	4	0	7	0	2	0	0	4	0	0
United States	67	82	7	0	0	25	35	2	1	1	0	11	1	0	1	0	4	14	39	2	6	0
Germany	21	42	3	0	0	2	17	1	0	0	0	1	0	0	0	0	2	1	0	0	37	0
Spain	53	9	2	0	0	46	7	4	0	0	0	0	0	0	1	0	0	0	1	3	0	0
South Korea	22	23	2	1	0	5	14	1	0	0	1	5	0	0	0	3	0	0	8	2	0	3
EPO	39	6	5	0	0	10	24	1	0	0	0	2	0	0	0	0	1	2	0	0	0	0
United Kingdom	15	24	3	3	0	6	4	0	0	0	3	3	3	0	0	0	0	0	12	0	2	1
Italy	9	4	4	0	0	3	2	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0
Canada	7	3	2	0	0	3	2	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Russia	7	2	4	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Japan	4	3	0	0	0	0	4	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
Portugal	3	3	0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
China	3	3	0	0	0	0	3	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Finland	0	3	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Switzerland	3	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	2	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Norway	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australia	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czechia	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Note: INPADOC patent families are assigned to the earliest filing in the patent family. Patent offices reported are those where AMU and ECOWAS member states applied for patents. Numbers presented are based on an approach developed by De Rassenfoss et al. to fill gaps in data in PATSTAT to provide analyses covering all patent offices in PATSTAT (see Appendix A for details). Source: Prepared by Science-Metrix using EPO, JPO and USPTO data indexed in PATSTAT (Spring 2019 edition)

To conclude this section, it is worth noting that AMU-ECOWAS contributions to INPADOC families spanned a total of 21 regional and national patent offices included in the PATSTAT database. While levels of activity are quite low in many of these offices, AMU-ECOWAS innovators have nevertheless achieved a truly international reach in their R&D activities over the period studied.

12. Conclusion

There is a growing consensus on the need of STI indicators for evidence-based decision making in Africa as demonstrated by the ongoing efforts in Africa to develop, adopt and use a common set of STI indicators at the national, regional and continental levels. Patent indicators as emphasised through the present project by the ECOWAS Secretariat and the African Observatory of Science, Technology and Innovation (AOSTI) of the African Union, will contribute to evaluating innovative activities and benchmarking national and regional innovation systems in the ECOWAS. The comparison of the ECOWAS' outputs for patent applications and patent grants shows that the output of the region for the 10 years (2006-2016) compiled from the WIPO data is smaller than the outputs of the two biggest performers of the continent, namely South Africa and Egypt taken individually. Two third of the patent applications from the ECOWAS are filed abroad, meaning that there is a need of national and regional patent offices and/or the improvement of patent application and granting processes for existing patent offices in the ECOWAS. Non-resident patent applications are higher than resident applications, meaning that the number of foreign innovators aiming to protect their innovations in the ECOWAS is higher than the number of ECOWAS innovators. For the indicators considered, the comparison of the ECOWAS member States to each other showed that the countries are at different levels and that concerted efforts are needed in the region to improve patent applications, the number of patent grants, and patent use.

The findings from the analysis of patenting activities (2005-2018) from various patent offices and patent families highlight a broad range of intensities in patenting activity across ECOWAS and AMU member states. Algerian, Moroccan and Tunisian inventors appeared to have the most sustained propensity to patent, and their countries held the highest patent counts in the USPTO, EPO and triadic families' data sets. Strong performances were also recorded for Niger and Nigeria in the USPTO and triadic families' data sets, but not with the EPO. AMU-ECOWAS innovators did not make sustained used of the ARIPO for reasons that cannot be fully elucidated here. Inventors from Benin, the Ivory Coast and Senegal made multiple filings with the OAPI within the short time frame for which data from this office are available. Ghana held a comparatively high number of applications that fell within triadic families, whereas Sierra Leone contributed to a notable number of INPADOC families originating at the German national office. Note that this assessment of top performances converges with those already reported in the recent GII report (although that assessment uses a much larger range of indicators).

Findings from the USPTO data set show sustained growth in the AMU and the ECOWAS filings moving from the 2005–2011 period to the 2012–2018 period (GIs of 1.6 and 1.3). This trend is replicated specifically for Tunisian innovators' filings with the national office, the OTDAV (GI of 1.2). These observations of growth are counterbalanced by stability or a slight decrease in filings between periods within the EPO and triadic families' data sets. Overall, the outlook for increased patenting activity within the AMU and ECOWAS regions appears to be carefully optimistic, although follow-up monitoring in upcoming years is desirable to confirm the trend.

AMU-ECOWAS innovators make their foreign patent claims in very high proportions as part of international collaborations (often more than 70% for USPTO and EPO filings; and 95% of applications falling in triadic families). International collaborations are commonly perceived as conducive to innovation. Nevertheless, a signal in this dataset that may be cause for more concern was also detected. Many AMU-ECOWAS patent applications falling within triadic families were coded as international collaborations because either the inventors or the assignees held concurrent affiliations to both African and either North American or European institutions, or to different regional branches of the same multinational organisation. Very high ICR figures were also noted for USPTO and EPO granted patents. Such a situation may indicate activities of transfer of innovation and expertise towards AMU-ECOWAS member states, but this signal could also capture the inverse movement: it could be that there is an "invention drain" away from member states. At stake here is whether the innovations referred to in AMU-ECOWAS patent claims with high ICR are appropriated locally or not. Further research would be required to obtain in-depth empirical observations on innovators with multinational affiliations and to determine how the question of local appropriation of inventions plays out in the specific context of AMU and ECOWAS member states.

Variability in findings when moving from one data set to the other reflects the fact that patenting practices in the AMU and the ECOWAS member states are complex and multifaceted. Although a moderate number of granted patents or patent applications were retrieved for Algeria generally, the country made numerous contributions to triadic families. And although Tunisia probably emerges as the leader in patenting activity in the sample of African states considered in the current analysis, grant or application counts from the EPO, the USPTO and other databases are still very far from the count retrieved from that country's national office's records, which is not in itself surprising, because countries tend to focus on their own internal market; however, it is still a reflection of the drive to export local innovation for economic purposes. Ghanaian filings that fell within triadic families were much higher than counts obtained in other data sets. Lack of empirical evidence on the pathways to innovation and practices of AMU and ECOWAS innovators in turn restricts capacity to produce technometric designs that are both accurate and cost-effective. In such a context, future exercises should aim to process data sets from as many patent offices as possible in order to capture the full diversity of strategies employed by AMU and ECOWAS innovators.

It was finally noted that given the fragmentary nature of African patenting data sets (in turn potentially reflecting multiple parallel pathways to innovation), much could be gained from the conduct of technometric studies employing non-conventional designs. A mixed team approach, centered around collaborations with national offices as well as offices such as the ARIPO and the OAPI, could help fill in gaps in data sets as these data are not easily accessible at the moment for research purposes. Qualitative field work or the conduct of surveys would provide valuable evidence for the interpretation of findings produced through quantitative patent analysis.

Patents are incentives to innovation by conferring exclusive rights and high returns on investments to innovators in regions where the contextual factors (including policies) are favourable. It is however important to note that global statistics on patents and technologies show that some important innovations are not patented. Therefore, while the ECOWAS region plans to increase its capacity to produce and use patents, the region must also explore alternatives to patents, such as trade secrecy and "first to the market" advantages, etc. Policies and decisions to improve these options include support to small and medium enterprises (SMEs) which make and/or commercialize products from ECOWAS innovations.

13. References

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14. Appendix

14.1 Database selection

Data for this study were prepared using the PATSTAT 2019 Spring edition, released in May 2019. PATSTAT, a product of the European Patent Office (EPO), contains bibliographic data from more than 100 million patent documents, covering 90 patent authorities, from both industrialised and developing countries. Over the years, it became a point of reference for patent analysis, emerging as the most frequently used database for scientific research (based on searches in bibliographic databases of scientific publications). Its exhaustive coverage enables users to prepare various analyses, and its content is frequently enriched following work from the community.

Because of PATSTAT's broad coverage, Science-Metrix suggested using it for the analysis of patents from the ECOWAS and AMU regions. Data from multiple patent offices could be retrieved in PATSTAT for member states of these communities. However, although PATSTAT's coverage is quite large, it does not cover all patent offices, because offices need to share their data with the EPO in order to be included, which is not always the case. Furthermore, the quality of the data is not identical across all offices, because some only share parts of the data covered in PATSTAT (e.g., the data from the Morocco patent office only cover documents and not inventors, which renders these data unusable for measuring patent activity based on geographical location). Following an assessment of the data from all the patent offices covered in PATSTAT, five offices were retained for this study: the United States Patent and Trademark Office (USPTO), the EPO, the African Regional Intellectual Property Organization (ARIPO), the Organisation Africaine de la Propriété Intellectuelle (OAPI), and the Tunisian Organism for the Protection of Copyrights and Related Rights (OTDAV).

However, even within this selection, data quality and coverage are not equal, and some data presented are more limited for some offices. For example, while data for the USPTO and EPO are mostly complete, data from the ARIPO suffer from a drop after 2016, which seems to indicate a lag in indexation of content in recent years. For the OAPI, data are only available up to 2007, which limited the analysis to a short period of three years. Finally, data from the Tunisian office only cover patent applications, because the status on patent grants is not available in PATSTAT for this office.

14.2 WIPO technology classification

The International Patent Classification (IPC), established in 1971, provides a hierarchical system based on symbols to classify patents according to different technological areas. It is enforced by most patent offices in the world, thereby providing a unified classification system. However, while this system is quite effective in classifying individual patents into its relevant technological areas, it is not perfectly suited for the preparation of statistics because its hierarchical levels are either too refined or not refined enough. Understanding the need for a proper system for analytical purposes, the World Intellectual Property Organization (WIPO), in collaboration with a team from the Fraunhofer Institute for Systems and Innovation Research, developed a classification of patents based on the IPC, grouping the hierarchical levels to create 35 technological areas. Since the inception of this classification, Science-Metrix has used it on multiple projects, most recently during the preparation of patent indicators for the 2018 edition of the National Science Foundation's Science and Engineering Indicators. One of the most positive factors regarding this classification is that it is freely available (www.wipo.int) , so any team can duplicate findings based on this classification as long as information on IPC patent codes is available. Given the popularity of the classification, it is now integrated into the PATSTAT database. Technological fields in this classification are not mutually exclusive, which results in a sum of patents across categories that is higher than the number of patents globally, unless fractional counts are assigned to each category. Because of the low levels of output measured in this study, we decided to report using the full counting method instead of using fractional counts.

14.3 Companion Databook Files

Provided as electronic files.

Notes

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ECOWAS (2005-2018)