Patent activity analysis: ASEAN countries and their collaboration with the EU28/AC

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1. Content

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List of Abbreviations

Abbreviation/Acronym	Meaning
ASEAN	Association of Southeast Asian Nations
AT	Austria
AU	Australia
BE	Belgium
BN	Brunei Darussalam
BR	Brazil
CA	Canada
CN	China
Co-pub	co-publications
DE	Germany
ES	Spain
EU	European Union
EU28	the 28 EU member states
EU28/AC	the EU28 plus the countries associated to the European Framework Programme for Research and Technological Development
FR	France
GB	Great Britain
HK	Hong Kong
ID	Indonesia
IN	India
IT	Italy
JP	Japan
KH	Cambodia
KR	Korea
LA	Lao PDR
MM	Myanmar
MY	Malaysia
NL	the Netherlands
NZ	New Zealand
PH	the Philippines
PK	Pakistan
pub	publications
RU	Russia
SA	South Africa
SE	Sweden
SG	Singapore
SM	Science Metrics
TH	Thailand
TW	Taiwan
UK	United Kingdom

2. Executive Summary

In the present report, we take a close look at patenting activity in Southeast Asia. We analyse patent application activity at major patent authorities in Southeast Asia in order to get a feeling for the intellectual property market and portfolio in the region. We go on describing patterns in national and international patent applications involving ASEAN-based inventors. Finally, we analyse patent activities by ASEAN-based applicants.

The analysis of patenting activity at major patent authorities shows two things: First, we see that the region is an important market for intellectual property. Patent filing activity has increased in all major patent offices. Second, there are major geographical imbalances. The majority of patent applications between 2003 and 2013 is filed either in Singapore or Malaysia. Technology-wise, the region as a whole shows a specialisation in technologies related to physics and electricity. Singapore and Malaysia also see a relevant inflow of patent families developed and first filed by inventors based outside of the region. However, not only patenting activity in Southeast Asia is increasing, but also patenting output involving ASEAN-based inventors.

From 2003 to 2013, the annual output of international patent applications with ASEAN-based inventors tripled. National patent application output grew by around 30%. While there is a considerable policy push promoting the increase in patenting, especially when it comes to international patents, it still shows that the innovative capacities in the region continue to increase. A look at the national level shows differences in the growth of patent applications. For example the output of Vietnam is growing extremely fast from a rather low baseline while Malaysia's national patent application output is decreasing, which seems to be caused by a public sector push towards international patents (the output of which is growing significantly).

ASEAN-based inventors not necessarily file their patent applications at ASEAN authorities. In fact, most national applications with ASEAN-based inventors are filed in the United States. This could have legal or economic reasons (US as a secure legal system for IP or as a target market) or reflect ownership structures of private sector patenting (offshore affiliates of US companies employing inventors in ASEAN). In contrast to this situation, most international patent applications are filed at ASEAN authorities. European intellectual property organisations are also much more important for these applications than in the case of applications filed through the national route.

Technology-wise, the region's knowledge production is highly specialised in national patent applications, while international patent applications do not show such a clear focus. Most national applications represent technologies needed for the production of semiconductors, computer technology, audio-visual technology, electoral machinery, apparatus, energy, measurement, and telecommunications. International applications most often are technologies for computer technology, audio-visual technology, semiconductors, medical technology and biotechnology.

Co-inventions, here understood as applications with inventors from more than one country, represent knowledge flows between different people, companies and regions. During the years 2003-2013, ASEAN-based inventors collaboratively developed 3,500 national and international patent applications respectively. When the result of a collaborative research process is a nationally

filed patent application, partners are most frequently based in the United States. Partners in European, Asian or ASEAN countries are less important. If the invention is getting filed as an international patent application, the most important partners are based in the United States and Europe. Technology-wise, partners from the US are particularly important for the development of national applications for semiconductors and computer technology. European partners are important for semiconductors and audio-visual technology. For international patent applications, partners from the US are most important in the development of semiconductors, pharmaceuticals and computer technology. European partners are most often involved in the development of technology in the fields of basic materials chemistry, organic fine chemistry and macromolecular chemistry and polymers.

The analysis of ASEAN-based applicants allows us to draw some other interesting conclusions. IP ownership in ASEAN is concentrated: The top 100 applicants own 81% of national and 65% of international applications involving ASEAN-based applicants. The ownership patterns of national and international patents only partially overlap. The most frequent owners of national patent applications are different from those of international patent applications, indicating that there are clear institutional strategies behind the chosen route of patent protection.

Technology-wise, the most important fields for ASEAN applicants are semiconductors, computer technology, audio-visual technology for 'A' and 'W' applications. But the technological specialisation on these fields is more pronounced for 'A' than for 'W' applications. For the latter, fields like biotechnology, medical technology or pharmaceutical play a more important role.

Two thirds of national patent applications and almost 90% of international PCT applications involving ASEAN-based applicants also involve ASEAN-based inventors. This means that the knowledge imports to the region by ASEAN-based IP owners are limited.

Conversely, foreign ownership, i.e. knowledge outflows are slightly more frequent: While national patents are owned by ASEAN applicants in more than the half of the cases, international applications are owned by ASEAN applicants in three quarters of the cases. Foreign ownership of applications filed nationally most often have applicants based in the United States, Taiwan and Korea. For international applications, the most common foreign ownership ties between ASEAN and other regions exist between Singapore and the EU, Singapore and the US, Malaysia and the EU as well as between Singapore and non-ASEAN Asian countries.

Technology-wise, the most common foreign owned national applications are from the fields semiconductors, computer technology, audio-visual technology, and electrical machinery, apparatus, energy. The highest numbers for foreign owned international patent applications concern civil engineering, computer technology, audio-visual technology, semiconductors and basic materials chemistry.

The scope and purpose of the SEA-EU-NET projects quantitative analyses required us to keep the present report descriptive. More sophisticated quantitative analyses could be a follow-up for the present report. For instance, it would be interesting to apply a social network analysis perspective to the material, deepen the analysis of patent families or combine the work on patent applications with the bibliometric study of publication output (looking for non-patent literature citations in patent

applications). Some of the descriptive findings moreover would require qualitative follow up work, e.g. in order to find out more about the foreign ownership and knowledge flow patterns (whether they are related to the presence of multinational companies' affiliates, to local research capacities, etc.). At this point, we hope the present report proves an interesting reference and data compendium for policy makers and analysts in ASEAN and beyond.

3. Introduction

3.1 Motivation and research question

Southeast Asia's research and innovation systems are changing. To varying extents, depending on which Southeast Asian country one is looking at, research and innovation performance is increasing. Data on research spending (public and private R&D investments) or the publication output (journal publications, international co-publications, etc) help to confirm and qualify this assessment. With the former only offering input indicators (budgets invested) and the second typically representing research activities (often academic research) rather than innovation, the set of indicators is not satisfactory. Another means to assess innovation output is through surveys[1], but national innovation surveys are only available in some Southeast Asian countries. In addition they are hardly comparable and disaggregated data is not available. In an effort to fill this gap, specific types of intellectual property rights (most notably patents) can be used as an additional indication of innovation output or, more precisely, invention activity.

Patent applications and patents have long been used as indicators of innovation output (cf. Griliches 1990; Nagaoka et al 2010). Conscious of the potentially misleading notion of innovation output, we consider patent applications and patents a viable and available indication of inventive activity and novel codified knowledge. Whether or not the inventive activity triggers innovations with actual economic or social impact is something that cannot be answered by patent statistics (there again surveys would be needed). With this limitation in mind, we make use of patent applications as an indicator of inventive activity in Southeast Asia[2]. We concretely aim to answer the following research questions:

- Is patenting activity in Southeast Asia increasing? If yes, where, in what fields and to what extent?
- How do dynamics of invention compare with IP ownership in Southeast Asia?
- What are the major players (owners of intellectual property and inventors) of Southeast Asian patent applications?

The SEA-EU-NET project has the mandate to analyse and support cooperative research and innovation activity between Southeast Asia and Europe. According to this mandate, this study goes beyond the analysis of patent application output in Southeast Asia. We are particularly interested in

[1] Often national and set up following the standards of the OECD Oslo Manual.

[2] In some sectors (like ICT) and for specific sub-questions (like marketing innovation), it would also be worthwhile to look at other types of intellectual property as innovation indicators. Given the size of the present study, this has not been possible. Likewise, we cannot provide a separate analysis of the so called utility models, which are lightweight patent-like forms of intellectual property (with less strict criteria of novelty, etc) that exist in some countries in the region.

the knowledge networks and cooperation patterns visible in Southeast Asia's patent application output. This results in the following additional research questions:

- To what extent is the inventive activity that takes place in Southeast Asia linked to other knowledge producing regions in the world?
- How does intra-regional cooperation compare to inter-regional cooperation?
- Are there specific patterns (geographic and thematic) in knowledge flows that are visible in patent application data?

In addition to answering these questions, we also link this patent application-based analysis with a bibliometric analysis of Southeast Asian journal publication output. Particularly in the analysis of geographic and thematic patterns of cooperation, this offers interesting new insights into the region's research and innovation activities.

3.1.2 Methodology and data

The following chapters illustrate the ASEAN scientific and technological activities using data on patent applications that are either filed at ASEAN patent authorities, are developed in cooperation with at least one ASEAN-based inventor or owned by at least one ASEAN-based entity. The first set of data on applications filed at ASEAN patent authorities can only cover those ASEAN countries whose patent authorities are in place and who are covered in PATSTAT. Analysis of ASEAN-based inventors and applicants is possible for all ASEAN countries. Our analysis builds on patent data received from European Patent Office's (EPO) PATSTAT database (version April 2014) as well as some complimentary queries in the PATSTAT Online database (version November 2015). The core of the analyses is the set of ASEAN-related patent applications filed in the period from 2003 to 2013. Patent applications filed before that period may be used for illustrating the dynamics of the region's patent application activity.

We deliberately use the term 'patent applications' instead of simply patents. Whether or not a patent application is actually granted depends on a number of factors, some of which have to do with the application's contents (a patent application might be found non-patentable), others with applicant strategies. Sometimes applicants only want to publish their invention in the form of a patent application in order to prevent others from protecting the same knowledge[3]. For our purposes, a patent application is a sufficient indication of novel, codified, potentially innovation-related knowledge that the applicants consider relevant enough to disclose.

Our core interest in this study lies in characterising not only patent application output as such, but also patterns of international cooperation in patent application output. During the last decades, an increase in the level of cooperation among researchers from different countries is observable, reflecting the greater openness and internationalisation of S&T activities. This information is found in patent documents which list inventors from different countries. Patent applications with multiple

[3] Once a specific piece of knowledge is published as a patent application (or any other forms that can be found by patent examiners), it counts as prior art for subsequent applications. As patents are not granted for already published knowledge, the patent application alone prevents subsequent applicants from securing a patent for the same piece of knowledge. For the initial applicant, this might be enough motivation for the application. A granted patent is not needed in this case. It is only needed if the applicant intends to sell or license the invention.

inventors from different countries (or applications that are filed under more than one technology class) can either be attributed to each country (or class) as a whole or as a fraction, based on the total number of regional and technological entities. Such patents can either be partly attributed to each country mentioned (fractional counts) or fully attributed to each country (whole counts). The methodological approach for the following analysis is the whole-count method (Dernis and Guellec 2001).

Different patent types exist that vary in procedure, costs, scope and subject of protection (e.g. registered design). The following analysis is based on two different types of patent applications. National (type 'A') patent applications are filed in a national or regional patent office and seek protection in a single market[4]. The patent office performs "searching and examining" the application in order to learn whether or not a patent may be granted, i.e. whether the invention is directed to patentable subject matter, is novel, inventive ("non-obvious to persons skilled in the art") and capable of industrial application. Independent of the outcome of this examination, the application is typically published around 18 months after the filing (at least in Europe; the time to publication varies considerably in Southeast Asian countries). After a positive so-called search report, which confirms to the applicant that the invention can be patented, the applicant decides whether or not to obtain a granted patent – and whether or not to pay the necessary fees.

As patents are territorial rights, the nature of national patent applications is that they have to be filed in each national office separately. Therefore, a set of national patent applications can refer to the same inventions. Concretely, after (or in parallel to) filing a national application for an invention (e.g. in the home or target market), subsequent national applications for the same invention can be filed at other offices. These are called secondary filings (compared to first filings) and, together with the first filing, constitute patent families. If a patent is filed in parallel at several national offices, their relation is not apparent. However, what happens more frequently is that applicants make use of a cost-saving procedure established with the Paris Convention for the Protection of Industrial Property, which all ASEAN Member States except Myanmar have signed: According to the Paris Convention, applicants in all of the 176 signatory states can first file a national application at their home office at a certain date, called the priority or first filing date. They then have a period of up to 12 months to file subsequent applications at other offices. For each of these subsequent filings, the same priority date applies. This means that the effective protection in case of an eventually granted patent starts with this priority date. For the sake of our study, it is interesting to distinguish the priority filings from subsequent filings as the former indicate the moment and place where the new knowledge was first disclosed. They are the first available indication for codified knowledge coming out of inventive activity. Unless otherwise stated, we therefore exclusively focus on first filings when analysing national patent applications.

Different from national 'A' patent applications, international 'W' patent applications are filed according to a procedure established under the International Patent Cooperation treaty (PCT). A PCT patent[5] can be filed in an IP office in one of the PCT signatory states, at a regional office (like the

[4] Applications to the European Patent Office (according to the European Patent Convention) are included in the ‚A' kind applications as European patent applications translate into a series of national patents in the EU Member States.

[5] For details on the PCT patent application process, see: http://www.wipo.int/pct/en/appguide/

European Patent Organisation EPO) or directly at the World Intellectual Property Organisation (WIPO). After the filing, it enters a so-called international phase followed by national phases in those countries (their IP offices, to be precise) the applicant selected for protection. In the end, the PCT application translates into a set of national patents (which are secondary filings to the first filed PCT applications). The advantage the PCT process offers is that it is cheaper than filing a series of national applications. The PCT application process is also easier and usually faster.

Applicants initially filing their invention in one or several national offices can still decide to apply for PCT protection later. In this case, the PCT application is actually a secondary filing to the national application. Inventions are frequently filed as national 'A' patents first. One reason for this can be that applicants seek an initial limited protection in their home or target market and decide later (when they can better assess the economic potential of the invention) whether or not to go for global protection. The application is then often filed under the PCT to increase the geographical coverage of the protection (OECD 2009). In the case of 'W' patent applications, the focus on first filings is not so relevant as we are interested in the moment and place where global protection for a certain invention is considered. We therefore analyse PCT applications regardless of whether they are first filings or secondary filings to earlier 'A' applications.

In our analysis, both 'A' and 'W' patent applications are considered in answering the research questions. 'W' applications are generally better comparable as the procedures are standardised. The OECD Patent Statistics Manual[6] actually advises against comparing 'A' level patent applications as scope and filing processes can differ substantially around the globe (affecting the numbers of application output). Nevertheless, Southeast Asian IP systems are comparable to either US or European (especially UK) models, ensuring a certain level of comparability within the region. We therefore analyse not only 'W', but also national 'A' patent applications. Other protectable characteristics like registered designs or utility models are not part of the study.

The coverage of both 'A' and 'W' patent applications is a particular advantage of PATSTAT as a data source[7]. As EPO's Worldwide Patent Statistical Database, PATSTAT encompasses over 80m records from around 90 patent authorities. Over 60m are national 'A' applications, around 3m 'W' applications (others include: utility models, translations, etc). While the coverage is not global, PATSTAT has the best possible approximate and aims to be globally comprehensive (unlike USPTO for instance). It covers all major patent authorities worldwide, including regional ones, as well as those 7 out of 10 ASEAN countries (only Cambodia, Lao PDR and Myanmar are not covered). Whereas the WIPO or OECD databases provide useful aggregates, PATSTAT offers interfaces for analyses at the level of individual patent applications. At this and other levels, there are also limitations in data quality: First, individual patent application records can have incorrect or missing information. One of the most frequent errors is the different spelling of applicant names. However, following EPO's collaboration with OECD and KU Leuven, PATSTAT now provides harmonised standard names.

A second data quality issue is the time lag. Most patent offices publish patent applications after a maximum of 18 months upon filing. This means that the newest applications that can technically appear in the 2014 version of PATSTAT have been filed at the beginning of 2013. Some authorities

[6] http://www.oecd.org/sti/inno/oecdpatentstatisticsmanual.htm

[7] As indicated above, we build on the April 2014 release of the database and punctually retrieve requests from PATSTAT Online Beta (November 2015).

take longer than that in publishing applications. In addition, EPO retrieves patent data from national authorities. These authorities' reporting speed varies greatly. This means that it takes between two and four years until most national records appear in the PATSTAT database. So while PATSTAT has the advantage of allowing for global comparisons of patent application output, data for recent years (in our case 2012 and 2013) is incomplete and cannot be interpreted. The situation is better for 'W'/PCT applications where EPO does not rely on national authorities' reporting, but on WIPO registers. Regardless of the time lag issue, PATSTAT is still the best possible source available for our purposes.

Regardless also of the type of patent application we are looking at, there is two other specificities of patent application data, which also makes it different from other scientometric data (e.g. data on journal publications): First, there are two types of actors involved in producing knowledge codified as patent applications: one or several inventors and one or several applicants. While the inventors are the individuals that developed the piece of knowledge, the applicants (often companies) are the ones who register and therefore own it. The knowledge is registered at a specific patent authority, which is the second specificity in patent application data. Particularly when discussing where a certain patent application was created, it is important to always keep in mind what level one is referring to: the level of the inventors of the knowledge, the owners of the knowledge or the place where the knowledge was first registered (filed for patent protection).

In the following chapters, we structure the presentation of our results along these three dimensions: First, patent applications are scrutinised on the level of the (national) patent authorities. Second, the patent activity of inventors based in ASEAN countries is analysed, followed by an analysis on the applicant level. Specific analyses of international cooperation patterns are integrated into the respective chapters depending on the level they address (inventors, applicants). However, before turning to the data, we will address the question of patent applications as indicators in more detail.

3.1.3. Patent applications as indicators

The Swiss Federal Institute of Intellectual Property (2014) defines patents as "titles conferring the right to an invention granted by intellectual property authorities. Legally, an invention is something that solves a technical problem with technology". The OECD's (2013) definition focuses less on the technology dimension and more on the aspects of publication and transfer of rights: „A patent is a right granted by a government to an inventor in exchange for the publication of the invention; it entitles the inventor to prevent any third party from using the invention in any way, for an agreed period".

Patents can thus be seen as an outcome of inventive and often research-intensive activity that is used most often by firms in order to protect and codify new knowledge. At the same time, patents are public and the knowledge they contain can thus be used to inspire further inventive activity[8].

[8] Whether or not the knowledge codified in patents is enough to follow up on the research that they embody, or whether significant tacit knowledge would be needed to do so, is a separate question that we will not discuss here.

Patents are protected and published results of inventive activities that contain codified knowledge on novel technological solutions.

From an innovation analyst's perspective, literature has long discussed the value of patents in order to assess innovation performance (e.g. Griliches 1990, Nagaoka et al. 2010). As the direct outcome of inventive processes aiming at commercial impact, patents seem to be an appropriate indicator to capture technological change, particularly the latter's competitive dimension (cf. Archibugi/Pianta 1996, 452). As filing patents is a costly process, it can be expected that applications are filed "for those inventions which, on average, are expected to provide benefits that outweigh these costs" (ibid., 453).

A number of drawbacks of patents as innovation indicators are also apparent, though: Not all inventions are technically patentable (software in most cases), neither are all technically patentable inventions patented. This depends on the sectors as well as on the specific technologies. Firms might opt to avoid the time and resource-consuming patenting process for strategic reasons. Their propensity to patent innovation varies. Furthermore, decisions on who features as inventor and as applicant (i.e. owner of the intellectual property) or where a patent is filed first are strategically taken, which analysts need to keep in mind when drawing conclusions. Pavitt (1988) also points to differences among countries in economic costs and benefits of patents, the rigor of exam, the subject matter coverage, etc.

Keeping these caveats in mind, patent applications and patents can be used as an indication for inventive activity (at a sector and country-wise varying level) and, relatedly, of innovations with potential economic or social impact. What actually happens to and with patent applications or granted patents is however difficult to estimate. The patent offices do not track information on actual use and commercialisation of patents, neither on mergers and company (and, thus, patent portfolio) acquisitions. Studies using survey methodology to get information on the usage and commercialisation of a limited set of patents estimate that around 40% of patents reach the market launch stage (Webster/Jensen 2011) or that around 65% of inventions involving academics are commercially used (Meyer 2006)[9]. In the early 2000s, the European PatVal-EU 1 Survey questioned the inventors of 9,017 patents granted by the European Patent Office (EPO) between 1993 and 1997 and found, among other observations, that around 36% of the patents are not used in any economic activities (Giuri et al. 2007). About half of these are so called 'blocking patents' that are neither internally used nor licensed, but block competitors. The other half are 'sleeping patents' with no use, not even in blocking competition. Another finding of the PatVal-EU 1 Survey is that large companies have higher shares of unused patents than SMEs (around 40% blocking and sleeping patents vs. around 20% in SMEs). Public research institutions and universities were found to also have around 40% of their patents unused. In a second wave of the PatVal-EU Survey, carried out from 2009 to 2011 for over 20,000 patents granted by the EPO between 2003 and 2005, this share was higher: 43% unused patents, and over 50% unused patents in public research institutions and large companies (Gambardella et al. 2012).

[9] mostly if they are produced already in collaboration with industry; of the purely academic inventions, only between 10 and 40% are commercially utilised

Among the patents that are commercially used, there exists a significant difference in their economic impact as Pakes and Griliches (1984) or Scherer and Harhoff (2000) have already pointed out. A very small number of patents is responsible for the largest part of the economic value in a firm's or a country's patent portfolio.

Patents are outputs of inventive processes with expected benefits. The patent application or granted patent itself offers no indication of economic value. Only a share of the patents granted generates economic returns, only a few of them most of the returns.

With these limitations in mind, patents can be an informative and relevant indication of inventive as well as research and development activity and a proxy pointing to economic and intellectual potential for innovation. This also and especially applies to collaboration in applied research, technology development and inventive activity. Studies show that the level of collaboration in technology and inventive activities has not reached the level of co-authorship in scientific research (Meyer/Bhattacharya 2004). The share of patents with a single inventor is significantly higher than in the case of academic publications and the relevance of small collaborations with two to three inventors is also higher than co-authorship networks of similar size (ibid., 449f). The reason for this is partly that co-inventions are still more of an intra-mural phenomenon involving small groups of inventors from one firm or research group only. Other reasons include strategic decisions and hierarchical considerations in assigning or not assigning patent "authorship". Different from publications, patents are legal documents. This also affects what kind of collaboration co-patents reflect, namely more formalised partnerships (compared to co-publications).

Studies (Bergek/Bruzelius 2010) have also shown that the majority of internationally co-invented patents are not the result of R&D collaboration in a narrow sense (as collaborative research between independent entities). In most cases, the collaboration takes place between subsidiaries of a firm or within the same firm rather than between completely independent firms. R&D advice, support in patent writing or other industrial services can also lead to the indication of a co-invention. If we take co-inventions as a proxy for research collaboration, what we get is an indication of invention-oriented collaboration in the broadest sense: between or within entities located in different countries, as a result of a variety of invention and research related activities. For our purposes in this aggregate analysis, this limitation is acceptable as we are interested in identifying and assessing innovation-related network linkages in the Southeast Asian region regardless of their intra- or inter-institutional nature. At this aggregate-level, international technological and invention-oriented collaboration results in knowledge flows between countries, in innovation networks and in externalities to other countries (De Prato/Nepelski's 2014).

Co-invented patent applications are an indication of collaborative invention-oriented activities (including, but by no means limited to collaborative research) carried out within a firm, between its subsidiaries or involving independent entities.

Generally speaking, the share of patents that are collaboratively produced and actually filed with more than one inventor is increasing. More importantly for us, the share of patents with inventors from at least two countries is still marginal, but increasing. Using the global patent application data of the European Patent Office's PATSTAT, De Prato and Nepelski (2014) calculated a share of internationally co-invented patents of 0.8% (6,229 out of 777,551) in 2007 compared to 0.18% in 1990 and 0.59% in 2000. The related growth rate in co-inventions is nearly ten times higher than the growth of patent applications. The global network of technological collaborations also grew to include a higher number of countries. It also became more integrated and denser (i.e. there are more patent co-invention links between a higher number of countries).

Another study using USPTO data (Guan/Chen 2012) reports a similarly strong growth in granted co-inventions at a higher base level: 1.23% international co-inventions in the period 1981-1985 compared to 2.41% for 1991-1995 and 4.5% for 2001-2005. The shares are similar to what Guellec and van Pottelsberghe de la Potterie (2001) found for patents filed at the European Patent Organisation: They report a share of international co-inventions of over 4% already in 1995. Interestingly, the PatVal-EU 1 Survey (Giuri et al. 2007) found that 15% of the surveyed 9,000 granted patents involved a co-inventor from outside the applicants firm (this is according to what respondents indicate, not according to patent data analysis). The share is slightly lower for firms as they tend to internalise the invention process.

The co-patenting share is not comparable with the share of co-authorship in academic articles, but it is growing.

The discussion on the reasons and exact mechanisms of this increasing techno-globalisation are ongoing. The literature points to an increasing number of countries participating in the global technological advances (Guan/Chen 2012), an increased capacity to codify and share knowledge across distances, enabling collaboration (Moreschalchi et al. 2015), increased mobility of scientists and engineers (Guellec/van Pottelsberghe de la Potterie 2001), the exploitation, decentralisation and related internationalisation of firms' R&D (Picci/Savorelli 2012; Penner-Hahn/Shaver 2005), etc. It should be taken into account that by far the largest part of patenting activity is firm-based, most of it in large corporations (Meyer/Bhattacharya 2004, 448), and that the dominance of firm patent holders especially applies to international co-patents (Picci 2010)[10]. As also indicated above, not only

[10] This links to discussions of the reasons of companies to decentralise and internationalise their R&D. The research on this indicates that firms might follow a strategy of exploiting home-based R&D, leveraging existing expertise abroad, or on augmenting the home-base, i.e. on seeking knowledge available only abroad (cf.

do multinationals and other firms own the largest part of internationally invented patents, but international co-inventions are in fact produced/invented within the same multinational firm or among its subsidiaries (Bergek/Bruzelius 2010). Nevertheless, co-patents are an indication of knowledge exchange and collaborative inventive activity between the countries involved. We can trace this activity at an aggregate level at some level of detail. Separating firm-based "intra-mural" and extra-mural international co-inventions from each other is not possible at a national-level aggregate scale due to the fact that inventor names cannot be traced to their potential (and changing) company affiliations (this could only be done for small samples allowing for inventor and firm surveys).

Recalling that most patenting activity is firm-based, there is, indeed, some indication in patent data, which can give us additional meta-level insights into transnational activities of firms: Apart from patent applications with inventors from two or more countries, there are patents where the applicant is from a different country than one or several of the inventors. This indicates knowledge flow out of the country of the inventor(s) and into the country of the applicant, i.e. towards the owner of the intellectual property (IP). Guellec and van Pottelsberghe de la Potterie (2001) showed that the share of this kind of foreign ownership of patents is more frequent than co-inventions (12% already in 1995). We can thus distinguish two major forms of international collaborative patenting activity:

- **Co-inventions**: Co-inventions represent the international collaboration in the inventive process. International collaboration by researchers can take place either within a multinational corporation (with research facilities in several countries) or through co-operative research among several firms or institutions (collaboration between inventors belonging to different universities or public research organisations). In that sense, co-invention indicators also reflect international flows of knowledge.
- **Foreign ownership**: Cross-border ownership of patent applications and patents reflects international flows of knowledge from the inventor country to the applicant countries and international flows of funds for research (multinational companies). In most cases, patents with inventors from abroad correspond to inventions made at the research laboratories of multinational companies and applied for at company headquarters (although in some cases national subsidiaries also may own or co-own the patents). Hence, this indicator expresses the extent to which foreign firms control domestic inventions.

Co-ownership (or co-application) would be a third kind of collaborative patenting: the presence of applicants from different countries in the same patent application. This also occurs, but it is considered a separate topic and is of limited interest to us here. There is literature discussing patterns of and reasons for patent co-applications (e.g. Hagedoorn 2003). It points to strong sectoral differences in co-applications that seem to be rooted in some sectors providing more legal security for firms to engage in co-applications as a kind of ex ante sharing of intellectual property.

Penner-Hahn/Shaver 2005; Kuemmerle 1997; Song et al. 2011). Niosi (1999) identified three purposes multinationals might pursue with locating research facilities abroad: adapting products to local markets; monitoring new technology developments occurring in foreign countries; and developing special technology using the partner country's comparative advantages. Yet another line of research (Patel 1995) points to the simple fact that after mergers and acquisitions, the buying company ends up with R&D facilities abroad. Besides these motives of knowledge and technology transfer, actual collaborative knowledge generation and innovation-oriented inventive activity is also observed (Archibugi/Iammarino 1999).

We distinguish two relevant kinds of collaborative patent applications (co-patents): Co-inventions, indicating networks engaging in collaborative invention-oriented activities, and foreign owned applications where the inventors and applicants are from different countries, indicating knowledge flow networks.

Patents are categorised according to the technology the invention represents. The most common classification system is the International Patent Classification (IPC) system that is rooted in the Strasbourg Agreement (1975). The IPC system provides for a hierarchical system of language independent symbols for the classification of patents and utility models according to the different areas of technology to which they pertain. The IPC divides technology into eight sections with approximately 70,000 subdivisions. (WIPO online 2016). The eight IPC sections are:

- A (human necessities)
- B (performing operations; transporting)
- C (chemistry; metallurgy)
- D (textiles; paper)
- E (fixed constructions)
- F (mechanical engineering; lighting; heating; weapons; blasting)
- G (physics)
- H (electricity)

Each section is divided into classes, subclasses, groups and so on. An example for an IPC class (normally revered too as IPC2) would be the class H01 (Basic electric elements), which contains the subclass (IPC3) H01S (Devices using stimulated emission).

Equipped with these conceptual clarifications, we can now approach the data and results of our patent application analyses. In the various sections, each addressing specific parts of our research questions, the practical use of these key concepts will become clear.

3.2. Patent activity by patent authority

In this chapter, an analysis of patent application output is conducted at the level of the national patent authorities. We do this to provide an overview of the size of the patent application output filed in the region. The number and type of applications received by an office provides information on the relevance of the respective country as a knowledge production and utilisation market.

As to the structure of the chapter: First, an overview of the total output is provided before the development over the period 2003-2013 is discussed. In the third part, the technological profile of patent applications in the ASEAN patent authorities is scrutinised. Patent families and first filings are described in the final part of this chapter.

3.2.1. Total records for ASEAN patent authorities until 2013

EPO's PATSTAT database includes patent application data from seven different patent authorities (national intellectual property offices - IPO) in ASEAN. The ASEAN countries with coverage are Brunei

Darussalam, whose patent bureau has been founded only in 2013, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. In EPO´s PATSTAT, no data is available on applications filed in Cambodia, Lao PDR or Myanmar. For the covered patent authorities, a total of 161,000 patent applications of all types are recorded in the EPO's PATSTAT (version April 2014). The oldest application dates from 1913. Patent applications are systematically collected since 1953 for the case of Malaysia, 1958 for the Philippines and around 1982 for the other office. All these patent applications include first filed applications, which represent newly generated knowledge, and all other applications that get extended to be protected in the respective country. The majority of these are national applications ('A'). The international PCT-patents ('W') account for around just 5% of all applications. Table1 provides an overview for the most important indicators.

Patent authority	Total counts	National patent applications 'A'	PCT-patent applications 'W'	Other IP applications	Share of PCT-patent applications 'W'	First filing counts	First filings as share of total
Brunei D.	2	2	-	-	0.0%	2	100.0%
Indonesia	14,848	12,457	62	2,329	0.4%	14,677	98.8%
Malaysia	41,541	39,999	1,504	38	3.6%	41,063	98.8%
Philippines	23,449	20,169	190	3,090	0.8%	23,384	99.7%
Singapore	80,324	74,368	5,709	247	7.1%	64,150	79.9%
Thailand	609	311	146	152	24.0%	609	100.0%
Vietnam	332	192	56	84	16.9%	329	99.1%
All	161,105	147,498	7,667	5940	4.8%	144,214	89.%

Table 1: Total number of patent applications per patent authority recorded in PATSTAT, distinguished by total count of applications, national and PCT-patent applications and first filings, Source: EPO, 2014

The most basic finding is that patent activity at the different IPOs is very unequally distributed. While just two patent applications are observed in Brunei Darussalam's newly founded IPO, more than 80,000 applications are recorded at Singapore's patent authority. Singapore and Malaysia are the two countries with the highest number of patent applications observed and account for more than three quarters of the region's total output.

The biggest share of all patent applications at ASEAN IPOs is made of national 'A' applications. This class of patents account for more than 90% of all recorded patent applications, while PCT and other types of patent applications account for 5% or 4% respectively. In total less than 8,000 'W' patent applications are recorded at ASEAN patent authorities.

The number of PCT-patent applications ('W') is even more concentrated at the Singaporean and Malaysian offices, with Singapore accounting for around 74% and Malaysia for another 20% of these applications in the region. In contrast, the highest shares of PCT-patent applications ('W') in national applications are observable in Thailand with 24% and Vietnam with 17%. At the patent authorities in Singapore and Malaysia, as the two countries with the highest number of PCT-patent applications, the shares are lower with 7% and 4% of all patent applications.

The number of PCT-patents is of particular interest as they grant international protection in selected countries. Also, as filing a 'W' patent is more expensive it can be assumed that these patents represent a higher expected economic value. Therefore, the concentration of PCT-patents in the economically and R&D investment-wise strong countries Singapore and Malaysia does not represent an unexpected geographical pattern. More of surprise, given the overall small patent base, are the

high shares observed in Thailand and Vietnam, but could possibly be explained by the activities of a few international companies or could result from specific university-level incentives or cooperation.

Other patent applications account for sizeable shares of overall output in Indonesia, the Philippines, Thailand and Vietnam. As we see in the following part, 99% of the patents that have been filed during the period 2003-2013 are either 'A' or 'W' patents. So the importance of other patent types is either decreasing or reported less frequently than in earlier years covered by the database – probably with the exception of Thailand. Anyway, the analysis undertaken for this report focuses on national 'A' and international 'W' patents filed under the Patent Cooperation Treaty (PCT).

The only country with a significant share of patent families, in contrast to first filings, is Singapore where these applications account for 20% of all applications. In all other countries, either no patent families have been registered (Brunei and Thailand) or their share is around one percent of all applications (Indonesia, Malaysia and Vietnam). The concentration of patent family filings at the patent authority of Singapore indicates not only the relevance of Singapore's market but also the role the city state plays as regional (knowledge) hub for international actors entering the ASEAN market.

3.2.2. Development during period 2003-2013

In period of 2003-2013, the number of patent applications at IPOs in the ASEAN countries is just short of 58,000 patent applications of all kind (see Table 2). This means that 36% of all recorded patents have been filed during the eleven years 2003-2013. Due to the delay between filing and publication of patent applications, these numbers have to be interpreted cautiously as the definitive numbers for the most recent years might change. Especially, as the observed numbers for the years 2012 and 2013 are below the previous averages. Against this background, in combination with the yet observable high share, it is clear that the knowledge production in the ASEAN countries has been gaining momentum during years before 2013.

Application authority	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Brunei Darussalam										2		2
Indonesia	6	7	11	13	19	13	17	16	13	12	4	131
Malaysia	2,355	2,570	2,396	1,980	1,428	1,041	699	756	583	425	107	14,340
Philippines	28	21	42	31	30	31	35	17	33	27	10	305
Singapore	2,307	3,294	3,764	3,222	3,397	2,921	3,731	7,301	8,097	3,940	577	42,551
Thailand	34	28	24	28	34	39	50	77	79	66	11	470
Vietnam	12	3	11	14	13	10	18	19	22	12	2	136
Total	**4,742**	**5,923**	**6,248**	**5,288**	**4,921**	**4,055**	**4,550**	**8,186**	**8,827**	**4,484**	**711**	**57,935**

Table 2: Development of patent applications of all kinds by patent authority during 2003-2013, Source: EPO, 2014

The total annual patent activity in the ASEAN region increased from a base line value of around 4,700 applications of all kinds in the year 2003 to around 8,800 in the year 2011. This represents an increase of 86% compared to the initial 2003 level. However, the output did not grow steadily but rose steeply in the years 2010 and 2011. This development is caused to a big extent by an increase of 'A' patents filed at the IPO in Singapore. The average annual output during the years 2003 to 2009 was around 5,100 applications and in the years 2008 and 2009 the output was below the 2003 level.

Again, this development varies between different countries within the region (see Figure 1). During the period 2003-2011, the highest growth is observable in Singapore, Thailand and the Philippines. Especially the increase of more than 250% in Singapore is particularly noteworthy as the growth starts form an already high base line. In contrast, the numbers of patent applications at the Malaysian patent authority were declining during the observed period[11].

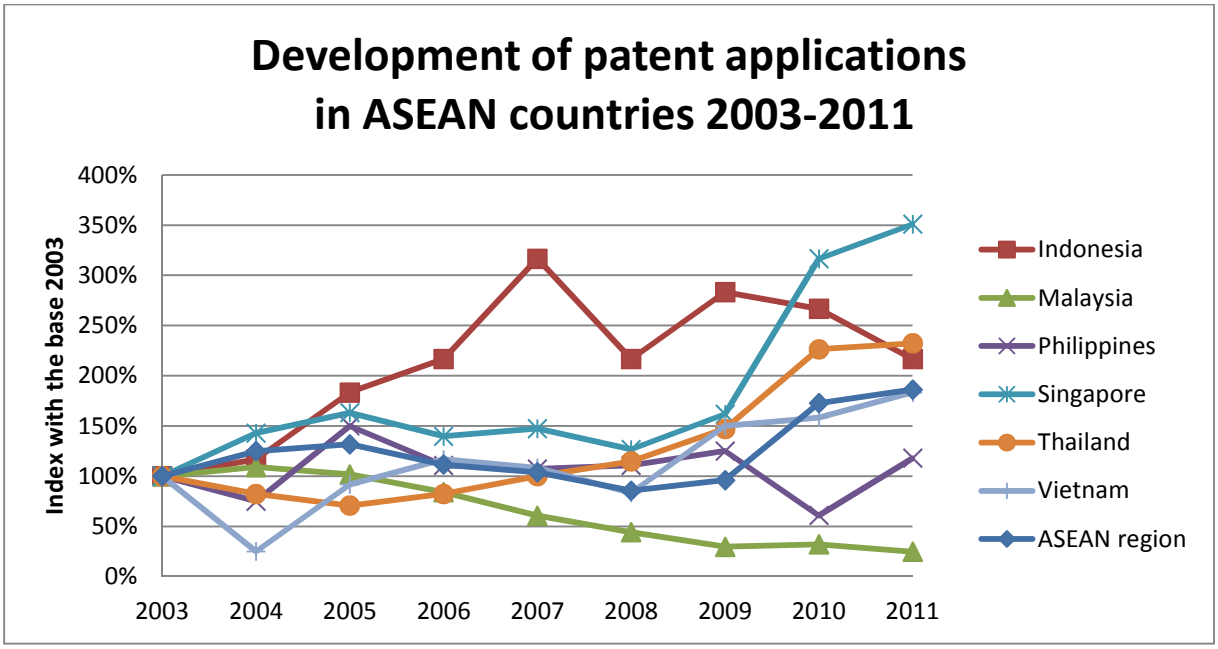


Figure 1: Index for development of patent applications of all kinds in ASEAN countries during 2003-2011, Source: EPO, 2014

In the period 2003-2013, a total of 51,000 'A' patents have been filed at ASEAN patent authorities (see Table 3). These 'A' patents account for 88% of all applications at ASEAN IPOs in the period 2003-2013. The region's ratio between 'A' and 'W' patent applications represents the situation in Singapore and Malaysia because most of the ASEAN patent applications are filed at one of these two IPOs. As these two IPOs account for nearly all (more than 50,000) 'A' patent applications that have been filed at ASEAN IPOs during 2003-2013, the ratio of 'A' patents to all patent applications are determining the situation for the ASEAN region as such.

The ratio between 'A' and 'W' patent applications in Singapore and Malaysia is 12% 'W' and 88% 'A' applications in the period 2003-2013. In other countries however, the situation is different. In Indonesia 60%, Philippines 41%, Thailand 47% and Vietnam 18% of all applications are national 'A' patents, which guarantee protection on the national but not on the international level.

[11] This observation is contrary to the authors' expectations. We double checked and found that the analysis is correct. Nevertheless, the actual patent activity in Malaysia might differ from the data recorded in EPO's PATSTAT Version April 2014 due to reporting issues.

Application authority	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Brunei Darussalam										2		2
Indonesia	5	4	9	6	13	7	15	7	6	7		79
Malaysia	2,355	2,570	2,396	1,947	1,336	844	473	423	333	152	1	12,830
Philippines	13	12	17	11	8	17	12	8	13	12	1	124
Singapore	2,010	2,858	3,327	2,804	2,950	2,420	3,215	6,809	7,639	3,506	337	37,875
Thailand	24	21	12	11	27	28	34	26	22	18		223
Vietnam	4	1	8	3	8	4	12	9	11	5		65
Total	**4,411**	**5,466**	**5,769**	**4,782**	**4,342**	**3,320**	**3,761**	**7,282**	**8,024**	**3,702**	**339**	**51,198**

Table 3: Development of 'A' patents by authority during 2003-2013, Source: EPO, 2014

During the timeframe 2003-2013, the biggest increase of 'A' patent applications is observable for Singapore where in 2002 just 2,000 and in the year 2011 more than 7,600 'A' patents have been filed. This represents a growth of more than 280% from a high base line value. According to the data available in PATSTAT, the number of 'A' patents has constantly decreased in Malaysia (while growth is observed in PCT filings at the Malaysian IP Office). Still, the country accounts for a quarter of all 'A' patents that have been filed in the ASEAN region during the period 2003-2013.

Application authority	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Indonesia	1		1	7	5	6	2	9	7	5	4	47
Malaysia				33	92	197	224	332	249	271	106	1.504
Philippines	13	9	24	18	17	12	20	8	19	15	9	164
Singapore	292	426	430	411	439	494	499	488	453	433	240	4.605
Thailand							4	47	49	35	11	146
Vietnam	7	2		9	3	4	4	5	11	6	2	53
Total	**313**	**437**	**455**	**478**	**556**	**713**	**753**	**889**	**788**	**765**	**372**	**6.519**

Table 4: Development of 'W' patents by authority during 2003-2013, Source: EPO, 2014

During the period 2003-2011, the relative increase of PCT-patent applications ('W') in ASEAN IPOs was even steeper than in the case of 'A' applications (see Table 4). With a total growth of more than 150%, the annual output of the ASEAN region rose from around 300 to around 800 PCT-patent applications per year between the years 2003 and 2011. The increase of PCT patents could indicate different things. First, the companies filing patents at ASEAN patent authorities have growing economic power and thus are able to file more expensive PCT patents. Second, the companies in ASEAN countries are increasingly active on global markets and therefore seek global protection of their intellectual property. Third, there are incentives for PCT filing on university and public research sector level (e.g. in Malaysia and Singapore).

Again, the growth of PCT-applications can mainly be attributed to Singapore, which is accounting for 73% of all PCT-patents during the period 2003-2011 (4,605 out of 6,519). But also for Malaysia, a significant growth is observable. At these two patent offices, 94% of all ASEAN PCT patent applications are registered.

3.2.3. Technological specialisation

The data quality for patent applications at ASEAN IPOs by (IPC) technology classes is rather poor for national 'A' patents in EPO´s PATSTAT. In the database, values are available for the IPOs of Singapore

and Malaysia but even those two are incomplete. For national 'A' applications at the Malaysian patent authority a total of 12,300 and just 9,500 for the Singaporean IPO are recorded. These numbers are below the total number of applications at these offices (25% of all Singaporean applications), even though they normally should be higher than that as a single patent can be assigned to more than one section.

Application authority	A	B	C	D	E	F	G	H
Malaysia	299	302	313	23	121	112	176	195
Singapore	35	62	25	6	22	27	161	122
Malaysia	8.04%	8.12%	8.41%	0.62%	3.25%	3.01%	4.73%	5.24%
Singapore	0.92%	1.62%	0.66%	0.16%	0.58%	0.71%	4.22%	3.20%

Table 5: National 'A' applications by patent authority and IPC-technology sections during 2003-2013, Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

The available data – patent applications filed at these IPOs with existing information on IPC classes – is depicted in Table 5. As the IPC information is missing for a critical number of applications, the overall shares per IPC section are low. According to the data available, most of the patent applications filed at the Malaysian IPO are assigned to the IPC sections C (chemistry; metallurgy), B (performing operations; transporting), A (human necessities) and H (electricity). The Singaporean patent applications are predominantly filed under sections H (electricity), G (physics) and C (chemistry; metallurgy). In contrast to national 'A' patent applications the data quality for 'W' patent applications filed under the PCT is much better. Data is available for the IPOs of Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

Application authority	A	B	C	D	E	F	G	H
Indonesia	12	13	4	2	9	6	7	1
Malaysia	303	221	293	8	82	107	446	432
Philippines	55	24	20	-	9	31	27	13
Singapore	959	855	976	34	163	223	1,541	1,378
Thailand	36	35	47	1	5	25	19	10
Vietnam	13	14	8	-	12	13	1	1
Indonesia	25.5%	27.7%	8.5%	4.3%	19.1%	12.8%	14.9%	2.1%
Malaysia	20.1%	14.7%	19.5%	0.5%	5.5%	7.1%	29.7%	28.7%
Philippines	33.5%	14.6%	12.2%	-	5.5%	18.9%	16.5%	7.9%
Singapore	20.8%	18.6%	21.2%	0.7%	3.5%	4.8%	33.5%	29.9%
Thailand	24.7%	24.0%	32.2%	0.7%	3.4%	17.1%	13.0%	6.8%
Vietnam	24.5%	26.4%	15.1%	-	22.6%	24.5%	1.9%	1.9%

Table 6: PCT-patent applications by patent authority and IPC-technology sections during 2003-2013, Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

PCT-patents filed at ASEAN patent authorities are not evenly distributed among the eight IPC-sections (see Table 6). The highest shares are observable for sections G (physics) with 31%, H (electricity) with 28%, A (human necessities) and C (chemistry; metallurgy) with 21% each. But as the

total amount of patents varies between the ASEAN countries, so does the technological profile specialisation.

Again, the technological profile of the ASEAN region mirrors the specialisation of Singapore and Malaysia as those two countries account for the vast majority of all PCT-patent applications. Nearly a third of all applications have been filed under sections G (physics) and/or H (electricity) in those two countries. This is of particular interest as a lot of IPC-subclasses from sections G and H are high-tech patents (Definition see Eurostat[12]). Nevertheless, to determine if those patents qualify as high-tech inventions, an analysis on higher technological granularity would be needed.

The patent activity at the IPOs in Indonesia, the Philippines, Thailand and Vietnam indicate lower specialisations in these areas. Overall, most of the patents filed at these authorities are assigned to sections A (human necessities) and B (performing operations; transporting). High share for sections E (fixed constructions) and F (mechanical engineering; lighting; heating; weapons; blasting) are observed for Indonesia and Vietnam. The Philippines also have a specialisation for technologies in section F (mechanical engineering; lighting; heating; weapons; blasting). Even though countries like Cambodia or Vietnam are known sites for the production of textiles there are just a few patents attributed to section D (textiles; paper).

In addition to the above analysis of patent applications by IPC sections, an analysis on the basis of the CPC classification (a slightly different thematic categorisation of patents developed by the triadic authorities) is conducted. The main difference between IPC and CPC classification is the section Y, where emerging technologies, which are not yet classified in one of the eight classic sections, are pooled. The analysis of patents by CPC is an attempt to work out the specialisation of the national IPOs in these emerging cross-sectional technologies, (see Table 7). But, again, the geographical coverage and the amount of available data are poor for 'A' patents by technology sections.

Application authority	A	B	C	D	E	F	G	H	Y
Malaysia	57	38	62	3	23	23	60	70	48
Singapore	153	272	132	7	69	99	408	502	81
Malaysia	1.53%	1.02%	1.67%	0.08%	0.62%	0.62%	1.61%	1.88%	1.29%
Singapore	4.01%	7.13%	3.46%	0.18%	1.81%	2.59%	10.69%	13.16%	2.12%

Table 7: National 'A' applications by patent authority and CPC-technology sections during 2003-2013, Sections of the CPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity); Y (general tagging of new technological developments; general tagging of cross-sectional technologies spanning over several sections of the IPC). Source: EPO, 2014

Nevertheless, the analysis of 'A' patent applications by CPC classification shows a similar pattern as 'W' patents for the countries with available data. Singapore has specialisations in sections G (physics) and H (electricity). Malaysia is also specialised in those two fields but additionally high shares in sections B (performing operations; transporting) and especially C (chemistry; metallurgy) are observable. Patent activity in section Y (Emerging Cross-Sectional Technologies) is the highest at the

[12] http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an6.pdf

Malaysian IPO where these applications account for more than 5% of all applications. In comparison to other sections these output is rather low.

The results of an analysis of 'W' PCT patent applications by CPC classification can be seen in Table 8.

Application authority	A	B	C	D	E	F	G	H	Y
Indonesia	10	13	3	2	7	6	8	1	5
Malaysia	288	220	291	8	77	109	438	424	74
Philippines	58	30	22	1	9	31	28	15	23
Singapore	881	909	996	43	156	225	1.559	1.405	246
Thailand	34	35	47	1	5	26	19	9	20
Vietnam	13	14	9		12	12	1	1	6
Indonesia	21,3%	27,7%	6,4%	4,3%	14,9%	12,8%	17,0%	2,1%	10,6%
Malaysia	19,1%	14,6%	19,3%	0,5%	5,1%	7,2%	29,1%	28,2%	4,9%
Philippines	35,4%	18,3%	13,4%	0,6%	5,5%	18,9%	17,1%	9,1%	14,0%
Singapore	19,1%	19,7%	21,6%	0,9%	3,4%	4,9%	33,9%	30,5%	5,3%
Thailand	23,3%	24,0%	32,2%	0,7%	3,4%	17,8%	13,0%	6,2%	13,7%
Vietnam	24,5%	26,4%	17,0%	0,0%	22,6%	22,6%	1,9%	1,9%	11,3%

Table 8: PCT-patent applications by patent authority and CPC-technology sections during 2003-2013, Sections of the CPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity); Y (general tagging of new technological developments; general tagging of cross-sectional technologies spanning over several sections of the IPC). Source: EPO, 2014

Along with the results of the analyses of 'W' patent applications by IPC sections, Singapore and Malaysia show specialisations in sections G (physics) and H (electricity). Indonesia, Philippines, Thailand and Vietnam are specialised in technologies A (human necessities) and B (performing operations; transporting). Vietnam, Thailand and the Philippines additionally show high shares in the sections F (mechanical engineering; lighting; heating; weapons; blasting) and the Philippines are also showing a high patent activity in section G (physics).

The main difference between the IPC and CPC classifications systems is represented through section Y (Emerging Cross-Sectional Technologies) in which patents in new technologies, which are not yet integrated in one of the eight traditional sections, are classified. In this section of 'future technologies' the highest specialisation is observed for the Philippines (14.0%), Thailand (13.7%), Vietnam (11.3%) and Indonesia (10.6%). Singapore (5.3%) and Malaysia (4.9%) have a surprisingly low share of patents filed under this section. A comparison between section Y for 'A' and 'W' patent applications is only possible under the assumption that the missing records for 'A' patent applications is evenly distributed among all sections. An analysis with section shares normalised by the total number of entries per section results in similar shares in the different CPC sections for 'A' and 'W' patent applications. This analysis indicates that the applications under section Y (Emerging Cross-Sectional Technologies) are lower for 'W' applications than for 'A' applications. But, again, it has to be pointed out that the data quality for 'A' applications at patent authority level is poor.

3.2.4. First filings and patent families

A patent family is a set of patent applications taken in multiple countries to protect a single invention by a common inventor(s) and then patented in more than one country. A first application is made in one country – the priority country– and is then extended to other offices. National 'A' patent

applications may be filed in more than one country to increase the geographical coverage of the granted protection. Applications filed under the PCT ('W' patent application) are first examined on a global level and if the application is suitable, the patent will be granted. In a second step the 'W' patent applications must go to a national phase to gain protection in each country separately.

Thus both processes have a national phase and the size of the patent family represents the number of involved patent authorities or countries respectively. The higher the mean size of a patent family is, the higher the geographical coverage of the protection. As filing patent applications is a costly process, one can assume that patents are submitted that have a higher expected economic value or are owned by international corporations who seek protection for their inventions for countries where they have locations.

As patent families are filed at more than just a single patent authority the origin of the family is of interest. Patent families that originate outside of the ASEAN region but get extended to an ASEAN authority represent a knowledge inflow and may be filed in the region because the owner has a production site here. On the other hand, patent applications that are first filed at ASEAN authorities represent local knowledge. In this case the size of the patent family is of interest for assessing the economic value of the invention.

Patent authority	Number of patent families	Mean size of patent families	Sum of 'A' patents extended to 'W'
Brunei Darussalam	2	2.0	-
Indonesia	79	3.8	62
Malaysia	12,577	14.9	8,462
Philippines	124	2.7	97
Singapore	22,310	15.0	8,044
Thailand	223	5.4	130
Vietnam	65	4.8	53
Total	35,380	14.8	16,848

Table 9: Number and mean size of 'A' patent families at ASEAN patent authorities, 2003-2013, Source: EPO, 2014

In EPO´s PATSTAT, more than 35,000 'A' patent families are recorded for the ASEAN patent authorities (see Table 9). The vast majority of these applications are filed at the authorities in Singapore and Malaysia. Compared to the total ASEAN ´A´ patent applications that amount to 58,000, around half of these are national applications that got extended to 'W' applications. The mean size of these patent applications is around 15, which means that these patent applications are protected in more than a dozen countries. However, the size of the families varies greatly between the different patent authorities. The regional family size represents the size of families that are filed in Singapore and Malaysia, the countries with the vast majority of all applications, while other countries show much lower family sizes. If we exclude those two countries, the regional mean family size of patent applications is around 3.7. This means that a high inflow of external knowledge is visible for Singapore and Malaysia, while other extra-regional organisations are less likely to extend the protection of their inventions to other ASEAN countries. This is even more striking when comparing all 'A' patent applications with the ones that were first filed at ASEAN patent authorities.

Patent authority	Number of patent families	Mean size of patent families	Sum of 'A' patents extended to 'W'
Brunei Darussalam	2	2,0	-
Indonesia	79	3,8	62
Malaysia	3,767	2,1	1,508
Philippines	124	2,7	97
Singapore	3,942	2,9	1,556
Thailand	223	5,4	130
Vietnam	56	2,9	44
Total	8,193	2,6	3,397

Table 10: Number and mean size of 'A' patent families which are first filed in ASEAN patent authorities, 2003-2013, Source: EPO, 2014

From the more than 35,000 ‘A’ patent families filed at ASEAN authorities only around 8,000 or around a quarter are first filings (see Table 10). Nonetheless, most of the families are filed in Singapore or Malaysia. Again, the regional picture mainly reflects the situation of Singapore and Malaysia which experience a high inflow of foreign patent applications. In contrast to this situation, all ‘A’ patent families registered in Brunei Darussalam, Indonesia, the Philippines and Thailand are first filed in respective countries. The mean size of patent families first filed at ASEAN authorities is also much lower than for all filed families. The highest mean sizes are observable for Thailand and Indonesia while the mean size of patent families from Malaysia is even under the region’s average.

The national ‘A’ patent families at ASEAN authorities show that Singapore and Malaysia are experiencing a high inflow of knowledge and are important hubs for knowledge and knowledge intensive production. Other countries in the region hardly profit from these knowledge flows. Inventions that are first filed at ASEAN authorities have a smaller average size. This is not a surprise, given the fact that the inflow represents patent applications of high economic value that are protected in multiple countries.

The situation for patent families protected under the PCT is similar to national patent applications described above. At the ASEAN patent authorities, more than 6,500 ‘W’ patent applications have been filed between 2003 and 2013 (see Table 11). More than 90% of these applications have been filed either in Singapore or in Malaysia. More than 80% of these applications were initially filed as ‚A’ patents and later extended to ‚W’. The mean size of the ‘W’ patent families is much smaller than those filed as a national patent.. The fact that the average size of ‘W’ patent families filed at ASEAN authorities is lower is due to one or several of the following factors: many applicants still use a series of national filings to protect their IP in different markets in Southeast Asia; most of the applicants from outside the region do not use the PCT to expand patent families to Southeast Asia; many of the PCT filings first filed in Southeast Asia did not yet realise the potential for a broader global protection. Separate analyses would be required to clarify the influence of each of those factors.

Patent authority	Number of patent applications	Mean size of patent families	Sum of 'A' patents extended to 'W'
Indonesia	47	3.1	43
Malaysia	1,504	2.8	1,375
Philippines	164	2.4	121
Singapore	4,605	4.5	3,751
Thailand	146	2.5	90
Vietnam	53	2.6	46
Total	6,519	3.9	5,426

Table 11: Number and mean size of 'W' patent families at ASEAN patent authorities, 2003-2013, Source: EPO, 2014

As Table 12 shows, just around a quarter of the 'W' patent families filed at ASEAN patent authorities are first filings and 80% of these have been filed in Singapore From nearly 1,600 'W' patent families, nearly 1,300 have been filed in the city state and another 200 families have first been registered in Malaysia. The other four patent authorities account for 120 patent families. Around 60% of the 'W' patent families, first filed in ASEAN, were first filed as national patents. The mean size of ASEAN patent families is around 2.8 and is the highest in Singapore and Malaysia being the only countries with an average family size above 2.

Patent authority	Number of patent families	Mean size of patent families	Sum of 'A' patents extended to 'W'
Indonesia	5	1.8	1
Malaysia	194	2.1	75
Philippines	52	1.4	15
Singapore	1,268	3.0	818
Thailand	61	1.7	16
Vietnam	2	1.5	1
Total	1,582	2.8	926

Table 12: Number and mean size of 'W' patent families which are first filed at ASEAN patent authorities, 2003-2013, Source: EPO, 2014

In this section, the patent activity has been described on the level of the national patent authorities. It is evident that the patenting in ASEAN has seen a dynamic development. All countries covered in EPOs PASTAT show an increase in patent activity. Nevertheless, the regional imbalances are obvious. The vast majority of patent applications are filed at authorities in Singapore and Malaysia. Technology-wise the region shows a specialisation in the IPC sections physics and electricity. Singapore and Malaysia also see a relevant inflow of patent families developed and first filed by inventors based outside of the region. In a next step the level of inventors based in the ASEAN region is analysed.

3.3. Patent activities by ASEAN inventors during 2003-2013

In this chapter, the ASEAN patenting activity is analysed on the level of inventors. While the analysis at patent authority level gave us information about the relevance of Southeast Asian markets for knowledge produced in and outside of the region, the inventor-level analysis allows us to answer questions of the type of inventive activity going on in Southeast Asia. We discuss productivity (output per population) and development over time of Southeast Asian inventive activities. We analyse how concentrated the inventive activity is at the level of countries and individuals. We combine the inventor and patent authority level in asking where the knowledge produced in Southeast Asia is filed as patent applications. And we will have a look at the thematic portfolio of inventive activities in patenting sectors in the region. For 'A' patents we only analyse patent applications that are first filings.

For the inventor-level analyses, patent applications are geolocated by the inventor's home address, which is specified in the patent application form. This is the common way to scrutinise the innovative performance of laboratories and researchers in a given country (Dernis and Guellec 2001). For inventors based in ASEAN countries, a total of nearly 12,000 'A' and 10,500 'W' patent applications are recorded in PATSTAT (April 2014) for the period 2003 to 2013 (see Table 13).

3.3.1. Total patent activity by ASEAN inventors

The highest total patent activity is observed in Singapore and Malaysia for both 'A' and 'W' patent applications. These two countries account for 85% of all ASEAN 'A' patent applications as well as for 87% of all 'W' patent applications (see Table 13). Altogether, the region's countries form three classes on the base of the total patent activity of inventors living in these countries. Singapore and Malaysia have by far the highest patent activity. Thailand, the Philippines, Indonesia and Vietnam show intermediate total patenting activity while inventors living in Myanmar, Cambodia, Brunei Darussalam and Lao PDR are involved in less than 10 PATSTAT indexed patent applications per year. The shares the countries have on the region's total output are very similar for 'A' and 'W' patent applications. The most striking trend here is that Singapore is the only country with a higher share of PCT than for national 'A' patent applications as nearly two thirds of the region's 'W' patent applications are filed by inventors based in the city state.

Inventor by country of residence	Number of 'A' patent applications, first filing	Number of 'W' patents applications	Share of regional 'A' patent applications	Share of regional 'W' patents applications
Brunei Darussalam	25	7	0.21%	0.07%
Indonesia	341	248	2.82%	2.36%
Cambodia	8	3	0.07%	0.03%
Laos	4	11	0.03%	0.10%
Myanmar	38	4	0.31%	0.04%
Malaysia	4,179	2,430	34.62%	23.15%
Philippines	556	439	4.61%	4.18%
Singapore	6,042	6,703	50.05%	63.86%
Thailand	632	671	5.24%	6.39%
Vietnam	525	154	4.35%	1.47%
Total	**12,071**	**10,497**		

Table 13: Number of patent applications involving inventors living in ASEAN counrries during 2003-2013, Source: EPO, 2014

The ASEAN countries have very different economical preconditions and differ strongly population-wise. Indonesia, as the region's most populous country, has a population of nearly 250 million people while Brunei Darussalam has a population of less than half a million. This situation makes it necessary to adjust the total patent applications by population to get a meaningful insight into the countries' patenting activity. Looking at patenting activity per one million inhabitants shows that the regional average of 'A' patent applications is around 40 applications per million inhabitants and 17 'W' patent applications per million inhabitants (see Table 14).

Country	Population (2013)	'A' patent applications 2003-2013	'W' patent applications 2003-2013	'A' patent applications per Mio. inhabitants	'W' patent applications per Mio. inhabitants
Brunei Darussalam*	406,200	25	7	61.55	17.23
Cambodia	14,962,591	8	3	0.53	0.20
Indonesia	248,818,100	341	248	1.37	1.00
Laos	6,678,899	4	11	0.60	1.65
Malaysia	29,947,560	4,179	2,430	68.54	39.85
Myanmar**	60,975,993	38	4	1.27	0.13
Philippines***	94,013,200	556	439	5.91	4.67
Singapore	5,399,200	6,042	6,703	1,119.05	1,241.48
Thailand**	67,911,720	632	671	9.31	9.88

Vietnam	89,708,892	525	154	5.85	1.72
Total	618,822,355	12,071	10,497	19.51	16.96

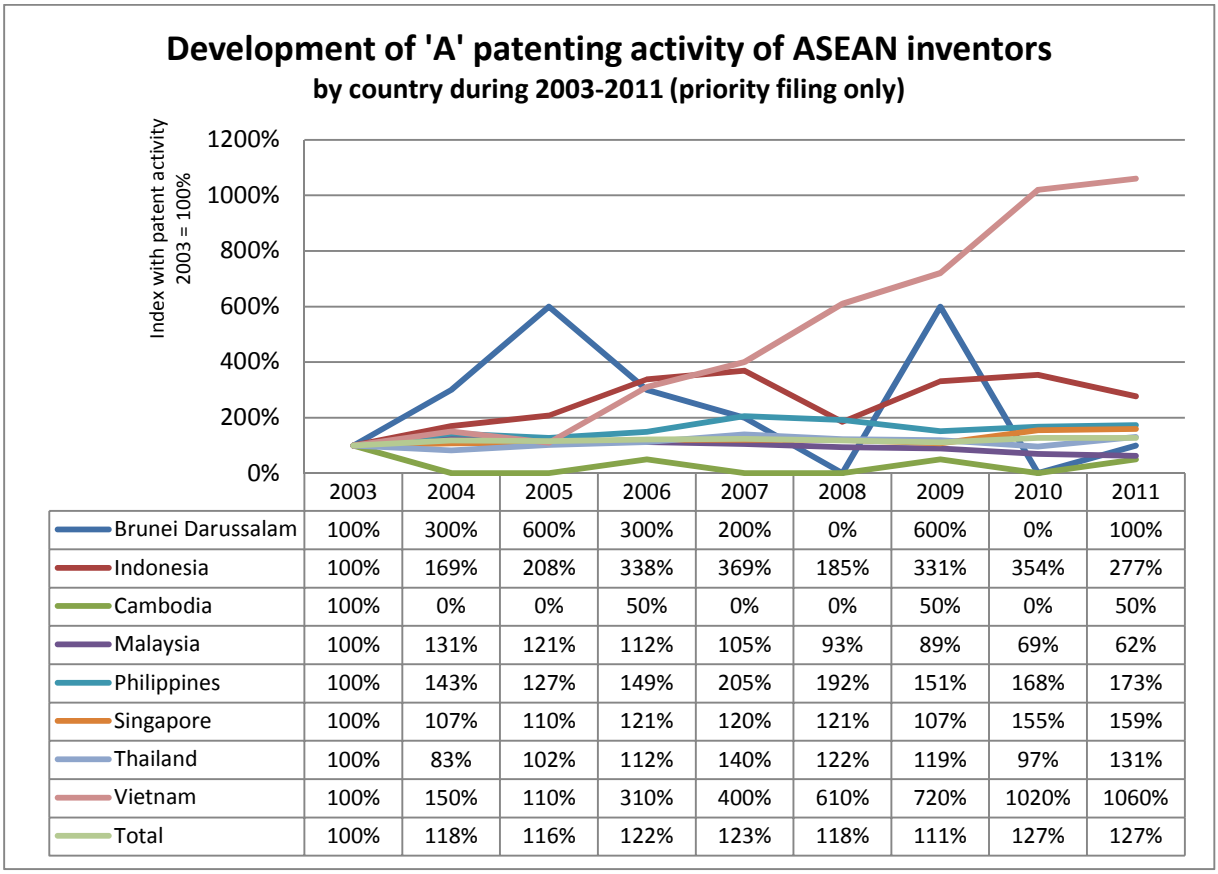
Table 14: 'A' and 'W' patent applications by ASEAN inventors per million inhabitants, 2003-2013, Note: * population data from 2009; ** population data from 2012; * population data from 2010; Source: UN, 2014; EPO, 2014**

At the country level, this analysis reveals a region-wide uniquely high level of patenting activity in Singapore. For the population-wise small city-state, the patenting activity per million inhabitants is sixty-times the region's average for 'A' patents and seventy-times the region's average for 'W' patent applications. For Malaysia, the observable patenting activity is also a multiple of the region's average values for patent applications per million inhabitants. Additionally, this analysis reveals that the small but wealthy Brunei Darussalam has a patenting activity that is twice the region's average for 'A' patent applications and an above average activity for 'W' patents. Beside these three countries, all other ASEAN countries have a patenting activity that is below the regional average per million inhabitants. In a next step the development over the timeframe 2003-2013 is analysed (see Table 15).

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Brunei Darussalam	1	3	6	3	2	-	6	-	1	3	-
Indonesia	13	22	27	44	48	24	43	46	36	24	14
Cambodia	2	-	-	1	-	-	1	-	1	3	-
Lao PDR	-	1	-	1	1	-	-	1	-	-	-
Myanmar	-	-	1	1	1	11	3	8	7	6	-
Malaysia	457	599	553	510	482	427	408	316	285	123	19
Philippines	37	53	47	55	76	71	56	62	64	31	4
Singapore	498	533	546	601	596	601	535	773	793	492	74
Thailand	58	48	59	65	81	71	69	56	76	40	9
Vietnam	10	15	11	31	40	61	72	102	106	71	6
Total	1,076	1,274	1,250	1,312	1,327	1,266	1,193	1,364	1,369	1,076	1,274

Table 15: Development of 'A' patent activity for of ASEAN inventors by country during 2003-2013, Source: EPO, 2014

In the year 2003, a little more than 1,000 'A' patent applications have been submitted with the involvement of a least one ASEAN-based inventor. There is a steady increase of applications observable until 2011, after that the annual output drops which is most likely caused by publication delays. Between 2003 and 2011 the region's output grew by 27%. In this year the highest number of patent applications is recorded with a little less than 1,400 'A' applications. The by far highest increase is observed for Vietnam, where, from a low baseline value, the patent activity grew by more than 1,000% (see Figure 2). Second highest growth rate is recorded for Indonesia where an increase of more than 170% is to be seen. The only two countries with less patent applications in 2011 than in 2003 are Cambodia and Malaysia. In Cambodia, the total output is so small that single data points should not be over-interpreted. The Malaysian situation is different and possible explanations range from the ordinary reporting lag, problems in EPOs database to a possible change in patenting policy. However, Malaysian inventors have been producing more applications until the year 2008, afterwards the numbers start to decrease beyond the 2003 level. The growth rates for 'A' patent applications for all other countries, with the exception of Brunei Darussalam, where the total output is rather low, range from an increase of 31% to 73%.



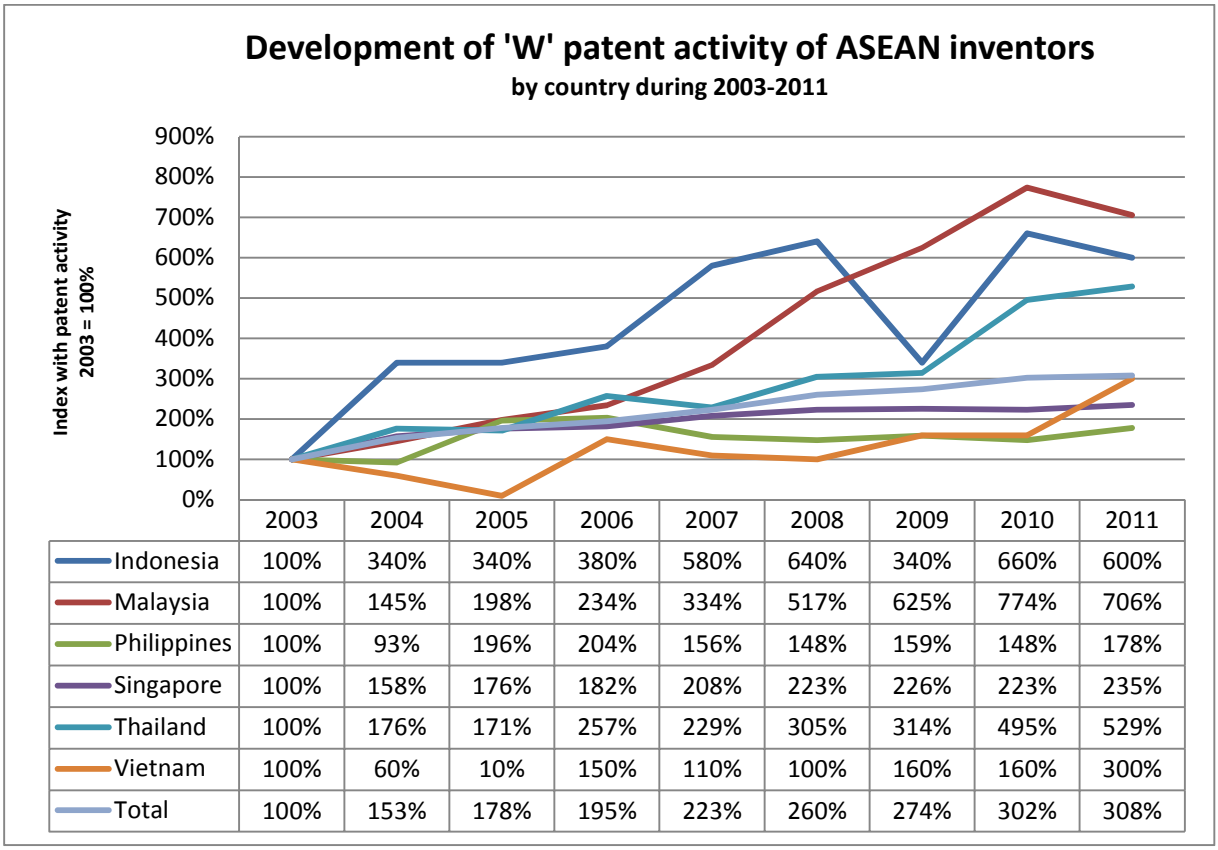
	2003	2004	2005	2006	2007	2008	2009	2010	2011
Brunei Darussalam	100%	300%	600%	300%	200%	0%	600%	0%	100%
Indonesia	100%	169%	208%	338%	369%	185%	331%	354%	277%
Cambodia	100%	0%	0%	50%	0%	0%	50%	0%	50%
Malaysia	100%	131%	121%	112%	105%	93%	89%	69%	62%
Philippines	100%	143%	127%	149%	205%	192%	151%	168%	173%
Singapore	100%	107%	110%	121%	120%	121%	107%	155%	159%
Thailand	100%	83%	102%	112%	140%	122%	119%	97%	131%
Vietnam	100%	150%	110%	310%	400%	610%	720%	1020%	1060%
Total	100%	118%	116%	122%	123%	118%	111%	127%	127%

Figure 2: Index of the development of 'A' patent activity for of ASEAN inventors by country during 2003-2011, Source: EPO, 2014

The development of patent applications filed under the PCT ('W' patent applications) is increasing even faster. During the period 2003-2011 the regional patent output grew by more than 200%.

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Brunei Darussalam					1	1		3		1	1
Indonesia	5	17	17	19	29	32	17	33	30	32	17
Cambodia		1		1							1
Lao PDR					2	1		3	1	3	1
Myanmar		1				1	2				
Malaysia	53	77	105	124	177	274	331	410	374	369	136
Philippines	27	25	53	55	42	40	43	40	48	46	20
Singapore	325	512	573	590	675	724	733	725	764	723	359
Thailand	21	37	36	54	48	64	66	104	111	90	40
Vietnam	10	6	1	15	11	10	16	16	30	31	8
Total	441	676	785	858	985	1,147	1,208	1,334	1,358	1,295	583

Table 16: Development of 'W' patent activity for of ASEAN inventors by country during 2003-2013, Source: EPO, 2014



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Indonesia	100%	340%	340%	380%	580%	640%	340%	660%	600%
Malaysia	100%	145%	198%	234%	334%	517%	625%	774%	706%
Philippines	100%	93%	196%	204%	156%	148%	159%	148%	178%
Singapore	100%	158%	176%	182%	208%	223%	226%	223%	235%
Thailand	100%	176%	171%	257%	229%	305%	314%	495%	529%
Vietnam	100%	60%	10%	150%	110%	100%	160%	160%	300%
Total	100%	153%	178%	195%	223%	260%	274%	302%	308%

Figure 3: Index of the development of 'W' patent activity for of ASEAN inventors by country during 2003-2011, EPO, 2014

The baseline value for the year 2003 is 441 'W' patent applications and in the year 2011 1,358 applications are recorded (see Table 16). The highest growth rate is seen in Malaysia with an increase of more than 600% with a baseline of more than 50 'W' patent applications in the year 2003 (see Figure 3). The accretions in Indonesia (500%) and Thailand (more than 400%) are also above the region's average but started from rather low baseline levels. The increase in Vietnam (200%), Singapore (135%) and the Philippines (78%) are below the regional average. But it has to be mentioned that Singapore is the only country starting form an already high baseline output in the year 2003. Actually, the city state's inventors accounted for three quarters of all 'W' patent applications in 2003 and were still responsible for more than half of the region's patent activity in 2011. After describing the dynamics of the patent activity of ASEAN-based inventors, the next question is where the patent applications are filed.

Inventor – patent authority links

During 2003-2013, ASEAN-based inventors developed more than 12,000 first filed 'A' patent applications (see Table 17). From these applications, only a fraction has been filed at patent authorities in ASEAN countries. 7,603, or over 60% of all patent applications developed by ASEAN-based inventors, have been filed in the United States.

Inventor by country of residence	Filed in… (patent authorities by region)							Total
	ASEAN	Asia	EU-28 incl. EPO	Non-EU Europe	North and Middle America (without the US)	South America	United States	
Brunei Darussalam	3	16	1	-	-	-	5	25
Cambodia	-	3	1	-	-	-	4	8
Indonesia	10	170	39	-	-	-	122	341
Laos	-	1	2	-	-	1	-	4
Myanmar	-	36	-	1	1	-	-	38
Malaysia	1,154	792	223	3	7	-	2,000	4,179
Philippines	10	80	19	2	6	2	437	556
Singapore	575	325	473	13	15	1	4,640	6,042
Thailand	14	105	148	1	3	2	359	632
Vietnam	1	445	22	18	3	-	36	525
Total	1,767	1,973	928	38	35	6	7,603	12,350

Table 17: 'A' applications with ASEAN inventors by regional filing authorities during 2003-201313, Source: EPO, 2014

Most patent applications from ASEAN-based inventors are filed in the United States followed by non-ASEAN Asian countries and ASEAN countries. Europe and other regions are playing just a minor role for national 'A' patent applications. The most important Asian countries are Taiwan and Korea while ASEAN inventors hardly file at the Chinese patent authority. In Europe, Germany and Great Brittan are by far the most important countries but smaller states like the Netherlands and Denmark also attracted more applications with ASEAN-based inventors than most other countries. Overall, around 20% of the applications of ASEAN-based inventors are filed within the ASEAN region. Nevertheless, differences between the ASEAN countries exist. For example, only one of the Vietnam-based 'A' applications has been filed in the region while Malaysia, where 2,000 'A' applications less than in Singapore were developed, is responsible for two thirds of all patent applications with ASEAN inventors filed in ASEAN countries.

During the period 2003-2013, a total of more than 10,000 'W' patent applications with at least one inventor based in an ASEAN country have been filed. In contrast to 'A' patent applications, which most often were filed in non-ASEAN countries, the majority of 'W' patent applications have been filed within the region (See Table 18).

Inventor by country of residence	Filed in… (patent authorities by region)									
	ASEAN	Asia	EU-28 Incl. EPO	Non-EU Europe	North and Middle America (without the US)	Oceania	South America	United States	WIPO	Total
Brunei Darussalam	1							5		7
Indonesia	70	23	23	1		11		48	35	248
Cambodia	1							2		3
Laos		5	1				1	1	2	11

[13] The number is higher than previous stated as double counting is possible. For example if a patent application is collaboratively developed by inventors from Singapore and Malaysia it is counted twice, once for each country/inventor.

Myanmar	3								1	4
Malaysia	1,592	46	101	4		38		353	130	2,430
Philippines	199	12	19	2	3	4		136	35	439
Singapore	4,150	232	202	11	11	71		939	567	6,703
Thailand	181	92	54	2	4	14		175	49	671
Vietnam	55	16	20	3	5	3		24	13	154
Total	**6,252**	**426**	**1,289**	**23**	**23**	**141**	**1**	**1,683**	**832**	**10,670**

Table 18: PCT-applications with ASEAN inventors by regional filing authorities during 2003-2013, Source: EPO, 2014

From 10,670 PCT patent applications with at least one inventor living in ASEAN countries, the vast majority with more than 6,200 applications or 59% of all applications are also filed at an ASEAN patent authority. Most patent applications filed at ASEAN authorities are filed in Singapore (41% of all applications) and Malaysia (14% of all applications). Inventors living in Myanmar, Malaysia, Philippines and Singapore file patents at ASEAN authorities more frequently than the regional average suggests.

As data in Table 18 shows, most ASEAN-invented patent applications that are filed outside the region are registered at patent authorities in the United States (16%), the EPO (8%) and the World Intellectual Property Organization (WIPO, 8%) or at national patent authorities in Asia (4%) and EU countries (4%). The relevance of these non-ASEAN authorities varies between the countries. The United States patent authority is most relevant for inventors form Brunei Darussalam and Cambodia and above-average shares for inventors living in the Philippines and Thailand. The WIPO is an important authority for inventors from Indonesia, Myanmar and Laos. The European Patent Office is of importance for inventors living in Brunei Darussalam, Indonesia, Thailand and Vietnam. As all these PCT-patents potentially ensure global protection (depending on the number of countries and national phases an applicant opts for). The difference might be explained by geographical cooperation patterns in co-patenting.

These observations indicate that if inventors seek global protection they will choose a local patent authority to file PCT-patents and if they seek a more simple protection they will choose the US authority to get protection for the most important market.

3.3.2. Technological specialisation

The 12,000 ‘A’ patents developed by ASEAN inventors are classified in one or multiple IPC sections so that there are more than 14,000 entries for patent applications per IPC section recorded. From these records (see Figure 4), more than 45% are attributed to section H (electricity). This indicates a clear specialisation on technology for electronic devices. The second biggest section is section G (physics) with another 27% of all applications. The sections A (human necessities), B (performing operations; transporting) and C (chemistry; metallurgy) account for between 9% and 13% of all records while sections D (textiles; paper); E (fixed constructions) and F (mechanical engineering; lighting; heating; weapons; blasting) only represent between 1% and 4% of the regions patent output.

Inventor by country of residence	A	B	C	D	E	F	G	H
Brunei Darussalam	-	5	-	-	2	6	6	9
Cambodia	5	-	1	1	-	-	2	-
Indonesia	69	46	56	2	21	2	83	109

Laos	2	1	2	-	-	-	1	1
Myanmar	-	2	6	-	-	-	14	21
Malaysia	406	513	335	24	150	258	1,237	1,605
Philippines	58	105	46	2	7	21	133	287
Singapore	302	657	385	12	86	146	1,639	3,266
Thailand	177	132	76	19	20	55	152	133
Vietnam	104	98	149	7	3	17	123	173
Brunei Darussalam	-	20.0%	-	-	8.0%	24.0%	24.0%	36.0%
Cambodia	62.5%	-	12.5%	12.5%	-	-	25.0%	-
Indonesia	20.2%	13.5%	16.4%	0.6%	6.2%	0.6%	24.3%	32.0%
Laos	50.0%	25.0%	50.0%	-	-	-	25.0%	25.0%
Myanmar	-	5.3%	15.8%	-	-	-	36.8%	55.3%
Malaysia	9.7%	12.3%	8.0%	0.6%	3.6%	6.2%	29.6%	38.4%
Philippines	10.4%	18.9%	8.3%	0.4%	1.3%	3.8%	23.9%	51.6%
Singapore	5.0%	10.9%	6.4%	0.2%	1.4%	2.4%	27.1%	54.1%
Thailand	28.0%	20.9%	12.0%	3.0%	3.2%	8.7%	24.1%	21.0%
Vietnam	19.8%	18.7%	28.4%	1.3%	0.6%	3.2%	23.4%	33.0%

Table 19: 'A' patents of ASEAN inventors by IPC sections, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

The technological specialisation of ASEAN inventors for the total region again corresponds with the specialisation of Singapore's and Malaysia's inventors. Singaporean inventors develop the most 'A' patents in sections H (electricity) with 54% and G (physics) with 27% share of all patents being filed in these classes (see Table 19). Malaysian inventors produce patents with 38% and 30% shares in these sections respectively. Other countries' specialisation patterns vary. For human necessities (A) shares above the regional average are noticeable for Indonesia, Cambodia, the Philippines, Thailand and Vietnam. Lao PDR and Thailand have a specialisation in performing operations and transporting (B). The highest shares for patents in section C (chemistry; metallurgy) are detectable in Indonesia, Cambodia, Lao PDR, Myanmar and Vietnam. Inventors from Brunei Darussalam have the most patent applications in sections F (mechanical engineering; lighting; heating; weapons; blasting) and G (physics).

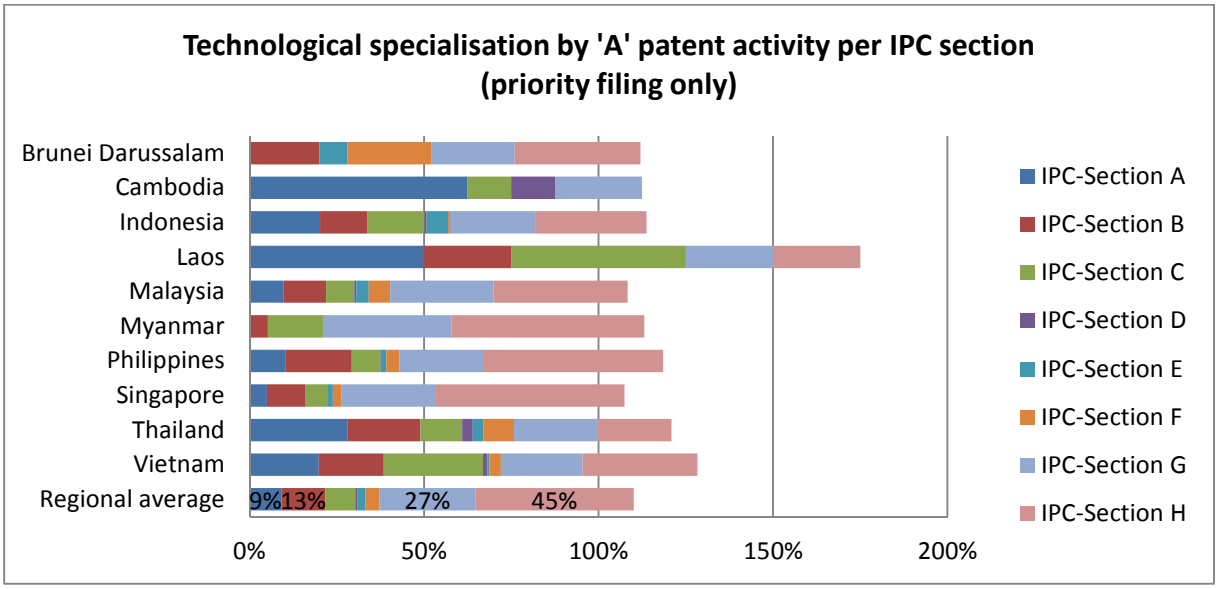


Figure 4: Technological specialisation by 'A' patent activity per IPC section, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed

constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

Technology field analysis

Another, and probably more intuitive, approach to aggregate patents is the technology field classification. International comparisons in economic studies are generally based on sector classifications, for instance, comparisons of production, employment, research and development or foreign trade. The production and function of products are based on technologies, and most products use a variety of technologies. In consequence, the notions of "sector" and "technology" describe different aspects of products and must be analysed separately. Patents are oriented towards the legal protection of technologies and therefore the classification of patents is based on technologies or products which use specific technologies. In many cases, the patent classification is quite similar to sector classifications, but they are never identical (Schmoch 2008).

The technology field classification system consists of 35 fields. As a single patent can be attributed to more than a single technology field, the total number of patents by technology field varies from the actual number of filed patent applications. ASEAN -based inventors were involved in the development of 12,000 'A' patent applications, which are classified in a total of 15,000 records by technology field.

Technological field	BN	ID	KH	LA	MM	MY	PH	SG	TH	VN
Electrical machinery, apparatus, energy	5	17	-	-	11	353	62	364	51	48
Audio-visual technology	2	23	-	-	5	387	30	702	50	27
Telecommunications	-	22	-	-	1	172	7	254	25	44
Digital communication	-	23	-	-	1	121	19	161	21	38
Basic communication processes	-	1	-	-	4	158	-	203	4	16
Computer technology	3	41	-	-	7	639	58	755	56	60
IT methods for management	-	9	-	-	-	27	21	100	8	5
Semiconductors	8	38	-	-	4	869	195	2,141	31	20
Optics	-	9	1	1	3	139	9	209	15	14
Measurement	-	15	-	-	1	347	17	314	35	36
Analysis of biological materials	-	2	-	-	-	15	4	34	2	14
Control	2	7	1	-	4	49	31	142	18	8
Medical technology	-	8	-	1	-	118	18	140	29	22
Organic fine chemistry	-	15	1	1	1	60	15	100	30	30
Biotechnology	-	13	-	-	1	77	11	93	16	40
Pharmaceuticals	-	6	4	1	-	72	10	71	23	53
Macromolecular chemistry, polymers	-	10	-	-	-	46	6	75	12	32
Food chemistry	-	30	1	-	-	63	4	21	39	18
Basic materials chemistry	-	12	-	-	-	115	6	69	13	27
Materials, metallurgy	-	8	-	1	1	43	7	60	7	40
Surface technology, coating	-	9	-	-	3	80	18	174	19	11
Micro-structural and nano-technology	-	7	-	-	-	36	4	38	2	24
Chemical engineering	-	13	1	1	-	97	14	126	23	32
Environmental technology	-	11	-	-	-	38	12	33	21	11
Handling	1	10	-	-	-	66	25	82	26	6
Machine tools	1	6	-	-	1	129	25	151	19	10
Engines, pumps, turbines	-	-	-	-	-	24	11	56	16	5
Textile and paper machines	-	6	-	-	-	38	11	114	23	15
Other special machines	3	10	-	-	1	94	13	107	34	20

Thermal processes and apparatus	1	-	-	-	-	35	4	38	19	-
Mechanical elements	-	1	-	-	-	63	8	48	16	11
Transport	-	1	-	-	-	67	11	42	21	11
Furniture, games	-	11	1	-	-	89	12	53	47	1
Other consumer goods	-	17	-	-	-	78	12	62	44	6
Civil engineering	2	21	-	-	-	150	7	86	20	3

Table 20: 'A' patent applications with ASEAN-based inventors by technology fields. 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); Source: EPO, 2014

On average, 993 patent applications are attributed to each technology field for the ASEAN region as a whole in the period 2003-2013. The technology field semiconductors is the by far most important class for ASEAN 'A' patent applications (see Table 20). Most of these patents were involving inventors living in Singapore (2.141 applications or 64%) or Malaysia (869 applications or 26%). In two other fields, more than 1,000 patent applications are recorded and another three fields have more than 500 records. The first group consists of technologies in the fields of computer technology (1,600) and audio-visual technology (1,200). More than 500 patent applications are recorded in the fields of electrical machinery, apparatus, energy, measurement and telecommunications. On average, half of the patent applications in these technology fields are developed by or in cooperation with inventors living in Singapore. More than a quarter of these applications include Malaysian inventors. Inventors based in Thailand are particularly important for the development of technologies in the fields of telecommunications.

The following Table 21 illustrates the shares of technology fields in each country in the total number of 'A' patent applications. As one patent application can be attributed to more than one technology field, the sum of shares for each geographical entity exceeds 100%. The results are highlighted if the share in the one technology field is above the regional average.

Technological field	**BN**	**ID**	**KH**	**LA**	**MM**	**MY**	**PH**	**SG**	**TH**	**VN**
Electrical machinery, apparatus, energy	17.9%	3.9%	0.0%	0.0%	22.4%	7.1%	8.6%	5.0%	6.1%	6.3%
Audio-visual technology	7.1%	5.3%	0.0%	0.0%	10.2%	7.8%	4.2%	9.7%	6.0%	3.6%
Telecommunications	0.0%	5.1%	0.0%	0.0%	2.0%	3.5%	1.0%	3.5%	3.0%	5.8%
Digital communication	0.0%	5.3%	0.0%	0.0%	2.0%	2.4%	2.6%	2.2%	2.5%	5.0%
Basic communication processes	0.0%	0.2%	0.0%	0.0%	8.2%	3.2%	0.0%	2.8%	0.5%	2.1%
Computer technology	10.7%	9.5%	0.0%	0.0%	14.3%	12.9%	8.1%	10.5%	6.7%	7.9%
IT methods for management	0.0%	2.1%	0.0%	0.0%	0.0%	0.5%	2.9%	1.4%	1.0%	0.7%
Semiconductors	28.6%	8.8%	0.0%	0.0%	8.2%	17.5%	27.2%	29.7%	3.7%	2.6%
Optics	0.0%	2.1%	10.0%	16.7%	6.1%	2.8%	1.3%	2.9%	1.8%	1.8%
Measurement	0.0%	3.5%	0.0%	0.0%	2.0%	7.0%	2.4%	4.4%	4.2%	4.7%
Analysis of biological materials	0.0%	0.5%	0.0%	0.0%	0.0%	0.3%	0.6%	0.5%	0.2%	1.8%
Control	7.1%	1.6%	10.0%	0.0%	8.2%	1.0%	4.3%	2.0%	2.2%	1.1%
Medical technology	0.0%	1.9%	0.0%	16.7%	0.0%	2.4%	2.5%	1.9%	3.5%	2.9%
Organic fine chemistry	0.0%	3.5%	10.0%	16.7%	2.0%	1.2%	2.1%	1.4%	3.6%	4.0%
Biotechnology	0.0%	3.0%	0.0%	0.0%	2.0%	1.6%	1.5%	1.3%	1.9%	5.3%
Pharmaceuticals	0.0%	1.4%	40.0%	16.7%	0.0%	1.5%	1.4%	1.0%	2.8%	7.0%
Macromolecular chemistry, polymers	0.0%	2.3%	0.0%	0.0%	0.0%	0.9%	0.8%	1.0%	1.4%	4.2%
Food chemistry	0.0%	6.9%	10.0%	0.0%	0.0%	1.3%	0.6%	0.3%	4.7%	2.4%
Basic materials chemistry	0.0%	2.8%	0.0%	0.0%	0.0%	2.3%	0.8%	1.0%	1.6%	3.6%
Materials, metallurgy	0.0%	1.9%	0.0%	16.7%	2.0%	0.9%	1.0%	0.8%	0.8%	5.3%
Surface technology, coating	0.0%	2.1%	0.0%	0.0%	6.1%	1.6%	2.5%	2.4%	2.3%	1.5%

Micro-structural and nano-technology	0.0%	1.6%	0.0%	0.0%	0.0%	0.7%	0.6%	0.5%	0.2%	3.2%
Chemical engineering	0.0%	3.0%	10.0%	16.7%	0.0%	2.0%	2.0%	1.7%	2.8%	4.2%
Environmental technology	0.0%	2.5%	0.0%	0.0%	0.0%	0.8%	1.7%	0.5%	2.5%	1.5%
Handling	3.6%	2.3%	0.0%	0.0%	0.0%	1.3%	3.5%	1.1%	3.1%	0.8%
Machine tools	3.6%	1.4%	0.0%	0.0%	2.0%	2.6%	3.5%	2.1%	2.3%	1.3%
Engines, pumps, turbines	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.5%	0.8%	1.9%	0.7%
Textile and paper machines	0.0%	1.4%	0.0%	0.0%	0.0%	0.8%	1.5%	1.6%	2.8%	2.0%
Other special machines	10.7%	2.3%	0.0%	0.0%	2.0%	1.9%	1.8%	1.5%	4.1%	2.6%
Thermal processes and apparatus	3.6%	0.0%	0.0%	0.0%	0.0%	0.7%	0.6%	0.5%	2.3%	0.0%
Mechanical elements	0.0%	0.2%	0.0%	0.0%	0.0%	1.3%	1.1%	0.7%	1.9%	1.5%
Transport	0.0%	0.2%	0.0%	0.0%	0.0%	1.4%	1.5%	0.6%	2.5%	1.5%
Furniture, games	0.0%	2.5%	10.0%	0.0%	0.0%	1.8%	1.7%	0.7%	5.6%	0.1%
Other consumer goods	0.0%	3.9%	0.0%	0.0%	0.0%	1.6%	1.7%	0.9%	5.3%	0.8%
Civil engineering	7.1%	4.9%	0.0%	0.0%	0.0%	3.0%	1.0%	1.2%	2.4%	0.4%

Table 21: ASEAN 'A' patent application shares by technology field, percentage based on the total number of national ´A´ patent applications. 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); Source: EPO, 2014

The ASEAN region shows a specialisation in the six technology fields described above. 22% of all 'A' patent applications involving ASEAN-based inventors are relevant for the technology field of semiconductors, 11% for computer technology (11%) and 8% for audio-visual technology (8%). Half of the patent applications for semiconductors are developed by Singaporean inventors. As illustrated in Table 21, the specialisation in this technology field is highest in Singapore (30%), Brunei Darussalam (29%) and in the Philippines (27% of all applications). Malaysia, where second most patent applications for semiconductors are developed, has 18% of its national ´A´ patent applications attributed to this technology field which is lower than the ASEAN average. Just two countries, Thailand and Cambodia, show no specialisation in the field of semiconductors.

In the technology field computer technology, the highest level of specialisation is observable in Myanmar (14%) and Malaysia, where 13% of all applications are attributed to this class. Singapore with a share of 11% is slightly under the regional average. The highest specialisations in the technology field audio-visual technology are noticeable in Myanmar (10% of all patent applications) and Singapore (10%). These are the only two countries with specialisations above the regional average.

Technological specialisation as measured by 'W' patent applications

Analogous to the analysis on 'A' patent application level, the technological specialisation of research output is also examined by the 'W' patent activity. As a single patent can be attributed to more than one IPC section, the 10,500 PCT-patents developed with the involvement of ASEAN inventors account for nearly 14,000 entries in the eight IPC-sections. The technological specialisation of the ASEAN region measured by PCT-patents is not as pronounced as it is for 'A' patents (see Table 22). Nevertheless, the IPC sections with the highest shares still are G (physics) with 29% and H (electricity) with 28%; closely followed by the sections C (chemistry; metallurgy) and B (performing operations; transporting) with 22% respectively. The section performing operations and transporting (B) has a share of 16% while the sections D (textiles; paper), E (fixed constructions) and F (mechanical engineering; lighting; heating; weapons; blasting) have shares between 2% and 6%.

Inventor by country of residence	A	B	C	D	E	F	G	H
Brunei Darussalam					4		2	1
Indonesia	67	50	61	14	34	12	37	25
Cambodia	2		1				1	
Laos	4	2	1		1	1	2	1
Myanmar			2					2
Malaysia	470	375	464	17	155	180	666	719
Philippines	116	60	58	1	14	34	96	139
Singapore	1,357	1,114	1,579	121	225	371	2,136	1,954
Thailand	221	143	174	17	29	59	119	92
Vietnam	55	38	39	3	15	17	20	19
Brunei Darussalam					57.1%		28.6%	14.3%
Indonesia	27.0%	20.2%	24.6%	5.6%	13.7%	4.8%	14.9%	10.1%
Cambodia	66.7%		33.3%				33.3%	
Laos	36.4%	18.2%	9.1%		9.1%	9.1%	18.2%	9.1%
Myanmar			50.0%					50.0%
Malaysia	19.3%	15.4%	19.1%	0.7%	6.4%	7.4%	27.4%	29.6%
Philippines	26.4%	13.7%	13.2%	0.2%	3.2%	7.7%	21.9%	31.7%
Singapore	20.2%	16.6%	23.6%	1.8%	3.4%	5.5%	31.9%	29.2%
Thailand	32.9%	21.3%	25.9%	2.5%	4.3%	8.8%	17.7%	13.7%
Vietnam	35.7%	24.7%	25.3%	1.9%	9.7%	11.0%	13.0%	12.3%

Table 22: PCT-patents of ASEAN inventors by IPC sections. 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

Again, the specialisation pattern of the overall ASEAN region mirrors the two countries with the highest patent activity, Singapore and Malaysia (see Figure 5). Countries with an above average share of patents in section A (human necessities) are Cambodia, Laos, Thailand, Vietnam, Indonesia and the Philippines whereas the total numbers for these countries are rather low. The highest shares in section B (performing operations; transporting) are noticeable in Indonesia, Thailand and Vietnam. The shares of patents in section C (chemistry; metallurgy) are highest in Cambodia and Myanmar whereas the total patent activity is very low in both countries. The technological specialisation of ASEAN inventors is more pronounced in 'A' patents. PCT-patents are more evenly distributed in the IPC sections.

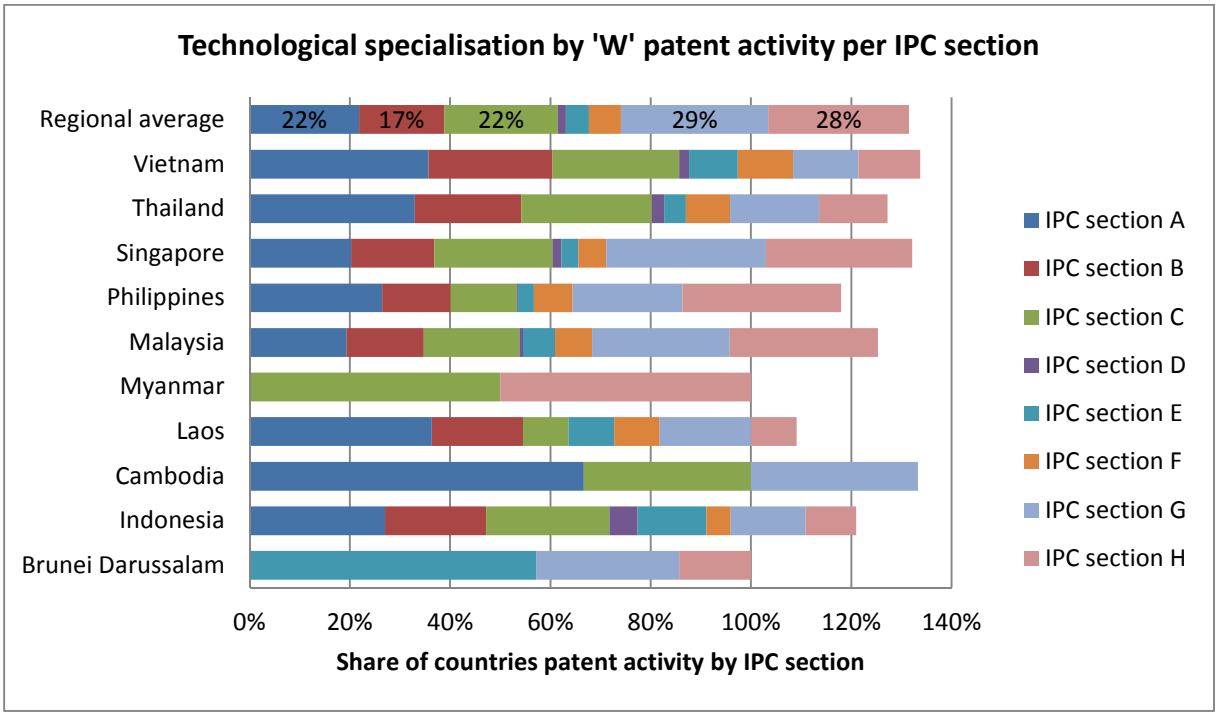


Figure 5: Technological specialisation by 'W' patent activity per IPC section, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

The 10,500 'W' patent applications (co-)developed by ASEAN-based inventors are attributed to a total of more than 15,600 technology fields. The difference between number of patent applications and patents by technology field, results from the fact that a single patent application can be assigned to more than one technology field. On average, one technology field contains 447 patent applications. A total of 15 technology fields have numbers above this regional average (see Table 23). These technology fields are 'electrical machinery, apparatus, energy', 'audio-visual technology', 'telecommunications', 'digital communication', 'computer technology', 'semiconductors', 'measurement', 'medical technology', 'organic fine chemistry', 'biotechnology', 'pharmaceuticals', 'basic materials chemistry', 'chemical engineering', 'other special machines' and 'civil engineering'.

Technological field	BN	ID	KH	LA	MM	MY	PH	SG	TH	VN
Electrical machinery, apparatus, energy	1	8		1	2	138	34	438	37	7
Audio-visual technology		1				88	14	635	30	4
Telecommunications		3				115	17	349	21	7
Digital communication		6				248	31	399	31	4
Basic communication processes						38		132	4	1
Computer technology		8				334	31	877	30	6
IT methods for management		8				71	35	237	14	2
Semiconductors		13				194	62	564	12	4
Optics	1	5	1			42	9	275	20	4
Measurement		8		1		162	11	401	20	2
Analysis of biological materials		2				64		246	14	3
Control	1	6				71	17	192	6	2
Medical technology		5		2		145	23	552	38	8

Organic fine chemistry		4			1	76	18	363	59	9
Biotechnology		15	1	1		126	7	604	47	8
Pharmaceuticals		16	2			126	15	497	69	11
Macromolecular chemistry, polymers		11				86	5	294	45	4
Food chemistry		14	1			79	25	95	37	6
Basic materials chemistry		27			1	170	26	298	34	18
Materials, metallurgy		8				42	14	156	24	10
Surface technology, coating		8				61	14	168	21	4
Micro-structural and nano-technology						30	2	187	2	3
Chemical engineering		10				120	7	378	34	12
Environmental technology		11		1		51	15	143	11	5
Handling		18				65	21	159	33	6
Machine tools		7				64	6	102	15	4
Engines, pumps, turbines		3		1		49	20	153	20	11
Textile and paper machines		13				20	3	104	14	5
Other special machines		17		1		85	9	265	53	18
Thermal processes and apparatus		3				40	7	92	16	1
Mechanical elements		2				54	6	80	18	6
Transport		6		2		59	12	128	35	7
Furniture, games		9		1		60	28	128	29	13
Other consumer goods		23				80	15	190	39	4
Civil engineering	4	34		1		155	14	225	29	15

Table 23: ASEAN 'W' patent applications by technology fields, 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); Source: EPO, 2014

From the total of 15,600 records for patent applications per technology field, around two thirds are developed by Singaporean and another 22% by Malaysian inventors. Inventions form these two countries account for 86% of all ´W´ patent applications per technology field. As described above, this illustrates that 'W' patent applications are highly concentrated within the ASEAN region.

The technology field with the most recorded patent applications is the field of computer technology with nearly 1,300 applications, which is about three times the regional average of patents per technology field. Nearly 70% of the applications in that field are filed by inventors based in Singapore and around a quarter can be attributed to Malaysian inventors. Inventors from those two countries are responsible for around 95% of all patent applications in the field of computer technology.

In five technology classes, at least 750 applications are recorded. These classes are audio-visual technology (772) where the vast majority (more than 80%) of applications are from Singapore. Applications in the field of semiconductors (849) are mostly developed by inventors from Singapore (66%) and Malaysia (23%). In the field of medical technology (773) around 71% of all applications are from Singaporean inventors and 19% form colleagues from Malaysia. Three quarters of the records in the field of biotechnology are developed by Singaporean inventors and another 16% by inventors based in Malaysia.

Technological field	**BN**	**ID**	**KH**	**LA**	**MM**	**MY**	**PH**	**SG**	**TH**	**VN**
Electrical machinery, apparatus, energy	14.3%	2.4%		8.3%	50.0%	4.0%	5.9%	4.3%	3.9%	3.0%
Audio-visual technology		0.3%				2.6%	2.4%	6.3%	3.1%	1.7%
Telecommunications		0.9%				3.4%	3.0%	3.5%	2.2%	3.0%
Digital communication		1.8%				7.3%	5.4%	3.9%	3.2%	1.7%
Basic communication processes		0.0%				1.1%		1.3%	0.4%	0.4%

Computer technology		2.4%				9.8%	5.4%	8.7%	3.1%	2.6%
IT methods for management		2.4%				2.1%	6.1%	2.3%	1.5%	0.9%
Semiconductors		3.9%				5.7%	10.8%	5.6%	1.2%	1.7%
Optics	14.3%	1.5%	20.0%			1.2%	1.6%	2.7%	2.1%	1.7%
Measurement		2.4%		8.3%		4.8%	1.9%	4.0%	2.1%	0.9%
Analysis of biological materials		0.6%				1.9%		2.4%	1.5%	1.3%
Control	14.3%	1.8%				2.1%	3.0%	1.9%	0.6%	0.9%
Medical technology		1.5%		16.7%		4.3%	4.0%	5.5%	4.0%	3.4%
Organic fine chemistry		1.2%			25.0%	2.2%	3.1%	3.6%	6.1%	3.8%
Biotechnology		4.5%	20.0%	8.3%		3.7%	1.2%	6.0%	4.9%	3.4%
Pharmaceuticals		4.8%	40.0%			3.7%	2.6%	4.9%	7.2%	4.7%
Macromolecular chemistry, polymers		3.3%				2.5%	0.9%	2.9%	4.7%	1.7%
Food chemistry		4.2%	20.0%			2.3%	4.4%	0.9%	3.9%	2.6%
Basic materials chemistry		8.1%			25.0%	5.0%	4.5%	2.9%	3.5%	7.7%
Materials, metallurgy		2.4%				1.2%	2.4%	1.5%	2.5%	4.3%
Surface technology, coating		2.4%				1.8%	2.4%	1.7%	2.2%	1.7%
Micro-structural and nano-technology						0.9%	0.3%	1.9%	0.2%	1.3%
Chemical engineering		3.0%				3.5%	1.2%	3.7%	3.5%	5.1%
Environmental technology		3.3%		8.3%		1.5%	2.6%	1.4%	1.1%	2.1%
Handling		5.4%				1.9%	3.7%	1.6%	3.4%	2.6%
Machine tools		2.1%				1.9%	1.0%	1.0%	1.6%	1.7%
Engines, pumps, turbines		0.9%		8.3%		1.4%	3.5%	1.5%	2.1%	4.7%
Textile and paper machines		3.9%				0.6%	0.5%	1.0%	1.5%	2.1%
Other special machines		5.1%		8.3%		2.5%	1.6%	2.6%	5.5%	7.7%
Thermal processes and apparatus		0.9%				1.2%	1.2%	0.9%	1.7%	0.4%
Mechanical elements		0.6%				1.6%	1.0%	0.8%	1.9%	2.6%
Transport		1.8%		16.7%		1.7%	2.1%	1.3%	3.6%	3.0%
Furniture, games		2.7%		8.3%		1.8%	4.9%	1.3%	3.0%	5.6%
Other consumer goods		6.9%				2.3%	2.6%	1.9%	4.1%	1.7%
Civil engineering	57.1%	10.2%		8.3%		4.5%	2.4%	2.2%	3.0%	6.4%

Table 24: ASEAN 'W' patent application shares by technology fields, percentage based on the total number of national ´A´ patent applications, 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); Source: EPO, 2014

Table 24 illustrates that 'W' patent applications are more equally distributed between different technology fields than 'A' patent applications. Very high specialisations are mostly observable in countries with a low total 'W' patent activity (e.g. Myanmar). One of the main differences between 'A' and 'W' patent applications per technology field on regional level, is that semiconductors are much more important for 'A' patents, where these technologies account for a quarter of all applications while the share for 'W' applications is only around 8%. In this field, the Philippines shows the highest specialisation with 14% of all applications. Another main difference between technology fields for 'A' and 'W' patent applications is that the ASEAN region shows higher specialisation in fields related to medical, pharmaceutical and biotechnologies.

3.3.3. Co-inventions

Co-inventions are defined as patent applications with more than one inventor. Due to increasing complexity of technologies and converging technologies, cooperation with external partner with complementing knowledge is essential for successful innovation processes. Especially, interactions between universities, research performing organisations and enterprises are important for transforming results of basic research into new applications (e.g. Hagedoorn and van Kranenburg 2003).

From the 12,000 'A' applications with at least on inventor living in ASEAN countries around 30% were developed as co-inventions[14]. Again, the highest total number for patent applications and co-inventions are observable for inventors living in Singapore and Malaysia but co-invention shares of these two countries are below the regions average while all other countries have co-invention shares above the ASEAN average (see Table 25).

Country	Number of 'A' applications	Single inventions	Co-inventions	Share of co-inventions
Brunei Darussalam	25	17	8	32%
Indonesia	341	203	138	40%
Cambodia	8	6	2	25%
Laos	4	2	2	50%
Myanmar	38	27	11	29%
Malaysia	4,179	3,117	1,062	25%
Philippines	556	301	255	46%
Singapore	6,042	4,410	1,632	27%
Thailand	632	362	270	43%
Vietnam	525	446	79	15%
Total	12,071	8,612	3,459	29%

Table 25: 'A' applications, co-inventions and shares of co-inventions by country, 2003-2013. Source: EPO, 2014

In the development of 'A' co-patent applications, inventors living in the United States are the most important partners for ASEAN inventors (see Table 26). Cooperation with US-based inventors accounts for more than 50% of all co-inventions. Many of these applications are also filed at the IPO in the United States. In contrast to PCT-patents, European partners are less important for the development of 'A' patent application and this cooperation pattern accounts for 22% of all observed co-inventions. This could indicate that if ASEAN and European partner cooperate, they are more likely going for a PCT-application instead of a national protection.

Country	Africa	ASEAN	Asia	EU	South America	United States
Brunei Darussalam		2	3	1		2
Indonesia		43	20	40	3	32
Cambodia				1		1
Laos				2		
Myanmar		8	1	1		1
Malaysia		196	119	213	5	529
Philippines		20	37	29		169
Singapore	1	13	301	363	8	946
Thailand		5	51	81	2	131
Vietnam			24	30		25
Total	**1**	**287**	**556**	**761**	**18**	**1,836**

Table 26: 'A' co-inventions with selected partner regions, 2003-2013. Source: EPO, 2014

Looking in more detail at the data for the EU, the most important European partner countries for ASEAN based inventors for the development of 'A' patent applications are Germany, Great Britain

[14] The analysis of co-inventors is done for those applications where BOTH inventor and applicant information is available in EPOs PATSTAT version April 2014. Data where either one is missing, are not part of the analyses. The total difference is around 500 applications with missing information.

and France. Cooperation with the regional actors in Japan, India and China accounts for around 16% each of all co-inventions with ASEAN partners. The cooperation levels represented by co-invention between the United States, Japan and China are independent from the choice of protection type. The shares of co-patents with these regions are on very similar levels for 'A' and 'W' patents.

Out of the more than 10,000 PCT patent applications with ASEAN inventors, 33% have been developed by more than just one inventor (see Table 27). While the highest total numbers for applications are again recorded for Singapore and Malaysia – these two countries account for more than 80% of all co-inventions – the share of co-inventions is the lowest in these two countries. All other ASEAN countries have a share above the regional average.

Country	Number of 'W' applications	Single inventions	Co-inventions	Share of co-inventions
Brunei Darussalam	7	3	4	57%
Indonesia	248	83	165	67%
Cambodia	3	-	3	100%
Lao PDR	11	6	5	45%
Myanmar	4	-	4	100%
Malaysia	2,430	1,762	668	27%
Philippines	439	260	179	41%
Singapore	6,703	4,678	2,025	30%
Thailand	671	287	384	57%
Vietnam	154	94	60	39%
Total	10,670	7,172	3,498	33%

Table 27: 'W' applications, co-inventions and shares of co-inventions by country, 2003-2013. Source: EPO, 2014

In the development of PCT-patents, the cooperation with inventors living in European countries or the United States is by far strongest (see Table 28). Inventors from both regions are involved in around 40% of all co-inventions with ASEAN inventors each. As country-level data on Asia reveals, around 9% of the co-invention partners are based either in Japan or China respectively. These patterns illustrate that ASEAN inventors are well connected with colleagues from western centres of knowledge production as well as to economically important partners in the Asia-Pacific region.

Country	Africa	ASEAN	Asia	EU	South America	United States
Brunei Darussalam		2	1	1		
Indonesia		37	27	61	3	37
Cambodia			1			2
Lao PDR		2		3		
Myanmar		3				1
Malaysia	1	99	94	243	2	229
Philippines		13	23	46	2	95
Singapore	6	20	461	735	3	800
Thailand	1	1	106	126	3	147
Vietnam			11	29		20
Total	**8**	**177**	**724**	**1,244**	**13**	**1,331**

Table 28: PCT-co-inventions with selected partner regions, 2003-2013. Source: EPO, 2014

Technological specialisation

In the next step, the cooperation patterns are analysed on more detailed level of IPC classification for bilateral cooperation within the ASEAN region as well as the cooperation between ASEAN countries and selected countries or groups of countries (EU-28 and BRICS). During the period 2003-2013, a total of 287'A' patents that have been the result of a collaborative development between inventors living in at least two different ASEAN countries have been filed. These patents represent inner-ASEAN cooperation patterns. Table 29 shows these cooperation patterns by IPC sections. The total numbers of patents per tie and technology section cannot be summed up for two reasons: a single patent application can be attributed to more than one IPC section; a co-invention involving more than two different countries is counted in more than one country-country link.

Cooperation partner by country of residence	Cooperation partner by country of residence	A	B	C	D	E	F	G	H
Malaysia	Singapore	22	42	10	-	-	6	110	270
Malaysia	Thailand	10	7	6	-	-	-	5	17
Philippines	Singapore	11	4	7	-	-	1	9	10
Malaysia	Philippines	1	3	6	-	-	1	9	18
Indonesia	Singapore	-	-	2	-	-	-	-	28
Singapore	Thailand	1	1	-	-	8	-	9	7
Indonesia	Malaysia	4	-	8	-	2	-	4	5
Indonesia	Vietnam	1	4	7	-	-	-	-	3
Malaysia	Vietnam	1	-	13	-	-	-	-	-
Myanmar	Malaysia	-	-	-	-	-	-	3	10
Indonesia	Thailand	2	-	8	-	-	-	1	-
Thailand	Vietnam	3	1	-	-	-	-	7	-
Indonesia	Philippines	-	-	2	-	-	-	-	7
Brunei Darussalam	Singapore	-	-	-	-	1	-	-	-
Brunei Darussalam	Malaysia	-	-	-	-	1	-	-	-

Table 29: Bilateral cooperation between ASEAN countries in common 'A' patent applications by IPC sections, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity) Source: EPO, 2014

The strongest tie between ASEAN countries is observable for the cooperation between Singapore and Malaysia, which are the two countries with the highest patent activity in the region. More than 50% of all bilateral co-inventions are developed in cooperation between inventors living in these countries. Most of these collaborative patents are attributed to IPC sections H (electricity) and G (physics). The other most important ties also include the two countries. These other important ties exist between Malaysia and Thailand, the Philippines and Singapore, Indonesia and Singapore, Malaysia and the Philippines, Indonesia and Malaysia and between Singapore and Thailand

As result of collaborative patenting, knowledge links between the ASEAN region and other countries or regions exist. Most recorded co-inventions include inventors from ASEAN countries and the United States, followed by Europe and BRICS countries (see Table 30). The highest numbers of links between these countries exist in IPC section H (electricity) where 40% of all ties to the United States, 26% of all ties to Europe and 41% of all ties to BRICS countries are observed. The second most important

section is G (physics) with 24% of all ties to the United States, 19% of all ties to Europe and 19% of all ties to BRICS countries.

Cooperation partner A by country of residence	Cooperation partner B by country of residence	A	B	C	D	E	F	G	H
ASEAN	United States	488	609	483	18	148	69	1,208	2,046
ASEAN	EU	310	266	399	22	62	49	396	542
ASEAN	BRICS	158	97	144	4	21	13	205	442
ASEAN	ASEAN	56	62	69	-	12	8	157	375
ASEAN	Asia	23	50	45	3	7	8	58	95

Table 30: Cooperation patterns between ASEAN countries and other countries in 'A' patent applications by IPC sections, 2003-2013[15] . Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). BRICS: Links between China, Brazil, India and South Africa exits. Source: EPO, 2014

When looking at the cooperation between ASEAN and BRICS countries in greater detail, the following patterns are revealed. Most of the connections exist between Singapore and China in the sections G (physics) and H (electricity); followed by Singapore to India and Malaysia to China that are also mostly attributed to sections G (physics) and H (electricity). Important links exist between Thailand and India as well as Malaysia and India.

Around 50% of all links between the ASEAN region and the United States exist between Singapore and the United States and more than a third of them are in the field of electricity (H). Other important knowledge ties exist between Malaysia, Thailand or the Philippines and the United Stated respectively. The shares between the technological fields are more or less the same for all ASEAN countries.

The most important ties between member states of the European Union and ASEAN countries exist between Germany or the United Kingdom and Singapore or Malaysia. The German-Singaporean cooperation is by far the most important link between the two regions with around a third of all recorded patent applications under section H (electricity). The link between Germany and Malaysia is the second strongest link. A third of these applications are classified under section H (electricity) and between 11% and 16% in the section A (human necessities), B (performing operations; transporting) and C (chemistry; metallurgy) respectively. The ties between the United Kingdom and Singapore are strongest in the sections H (electricity) and G (physics) while the cooperation between the United Kingdom and Malaysia is concentrated in A (human necessities). Other important ties exist between France and Singapore, Germany and Thailand as well as between the United Kingdom and the Philippines.

The links between ASEAN countries and the BRICS countries are strongest between Singapore and China and Singapore and India. These two links account for 60% of all links between these two groups of countries. The cooperation between Singapore and China is also strongest in the sections H

[15] Table 30 includes double counting and actual numbers might differ. For example a patent between one inventor based in Singapore and two colleagues living in Germany and France is counted as two links between ASEAN and EU28.

(electricity) and G (physics) while the connection to India is concentrated on sections A (human necessities), H (electricity) and G (physics). Other important ties between ASEAN and BRICS exist between Malaysia and China, the Philippines and China as well as between Thailand and China. From the BRICS countries, Russia is the only country without co-invention tie to the ASEAN region but the connections to South Africa and Brazil are weak as well.

The cooperation patterns analysed above for IPC section are now analysed on level of the technology field classification. It, again, has to be mentioned that a patent can be attributed to more than one technology field and therefore row totals presented in ***Table 31*** might differ from the actual level of patent activity. Additionally, the aggregation of single countries into regions implies that patent applications between more than two countries are counted multiple times. Nevertheless, the following table provides an overview of cooperation patterns between the ASEAN region and other regions by technological fields.

Technology field	Bilateral ASEAN	United States	Asia	BRICS	EU28	Row total
Electrical machinery, apparatus, energy	19	139	7	39	40	244
Audio-visual technology	37	164	17	23	70	311
Telecommunications	12	80	4	17	33	146
Digital communication	4	58	1	22	28	113
Basic communication processes	8	58	0	18	9	93
Computer technology	25	356	13	73	77	544
IT methods for management	9	45	0	10	15	79
Semiconductors	109	520	33	111	114	887
Optics	14	59	2	9	24	108
Measurement	15	105	11	21	32	184
Analysis of biological materials	2	12	0	8	11	33
Control	4	43	4	14	22	87
Medical technology	12	60	0	7	54	133
Organic fine chemistry	2	52	4	30	33	121
Biotechnology	5	38	3	11	25	82
Pharmaceuticals	8	42	4	23	31	108
Macromolecular chemistry, polymers	10	30	6	8	42	96
Food chemistry	1	24	0	7	21	53
Basic materials chemistry	9	56	4	12	33	114
Materials, metallurgy	3	18	1	15	23	60
Surface technology, coating	10	76	5	14	31	136
Micro-structural and nano-technology	3	19	4	2	10	38
Chemical engineering	12	58	2	22	38	132
Environmental technology	6	15	2	9	17	49
Handling	2	42	3	3	16	66
Machine tools	8	47	4	11	34	104
Engines, pumps, turbines	3	4	0	2	8	17
Textile and paper machines	5	46	7	1	16	75
Other special machines	13	50	1	15	30	109
Thermal processes and apparatus	1	15	0	3	7	26
Mechanical elements	2	16	3	1	4	26
Transport	2	16	8	2	16	44
Furniture, games	2	33	0	2	9	46
Other consumer goods	2	40	2	4	15	63
Civil engineering	6	70	2	11	34	123

Table 31: Co-inventions between ASEAN and other regions for 'A' patent applications by technology fields, 2003-2013. BRICS: Links between China, Brazil, India and South Africa exits. Source: EPO, 2014

The highest co-invention activity for 'A' patent applications is observable in the technology fields semiconductors, computer technologies, audio-visual technology, digital communication and organic fine chemistry. In general, the most co-inventions are developed in cooperation of ASEAN inventors and US-based inventors, followed by cooperation between ASEAN and European inventors. The bilateral cooperation within the ASEAN region is strongest in the technology field of semiconductors. In absolute numbers, the cooperation between ASEAN and US inventors is also concentrated in the field of semiconductors. The highest shares US inventors have in ASEAN co-inventions are recorded in the fields furniture and games, IT methods for management, measurement, civil engineering and computer technology.

The highest total numbers for co-inventions developed from ASEAN and European-based inventors are observed in the fields of semiconductors and organic fine chemistry. The relative importance is the highest in the fields of organic fine chemistry, basic materials chemistry, Macromolecular chemistry, polymers, food chemistry, pharmaceuticals and biotechnology. Most patent applications that are a result of cooperation between Japan and ASEAN-based inventors are observable in the fields of audio-visual technology, semiconductors, computer technology and digital communication. The cooperation between Japan and ASEAN has the highest relative importance in the fields of transport, audio-visual technology, mechanical elements, materials, metallurgy and textile and paper machines.

Co-inventions between ASEAN and BRICS-based inventors are most often attributed to the fields semiconductors, digital communication, computer technology and audio-visual technology. The relative importance between these two groups of countries is the highest in the fields digital communication, telecommunications, basic communication processes, semiconductors, electrical machinery, apparatus, energy, materials, metallurgy, food chemistry and thermal processes and apparatus.

Co-invention by 'W' patent applications

For 'W' patent applications filed under the PCT, the bilateral cooperation within the ASEAN region is more or less reduced to the link between Singapore and Malaysia. This tie accounts for more than the half of all observed connections (see Table 32). The second most frequent connection between Singapore and Thailand just accounts for around 10% of all ties. Technology-wise, the bilateral ASEAN cooperation is less concentrated on physics (G) and electricity (H) when described via PCT patent applications compared to 'A' patent applications. For PCT/'W' patent applications, the connections are evenly distributed to sections A (human necessities), C (chemistry; metallurgy), G (physics) and H (electricity).

Cooperation partner A by country of residence	Cooperation partner B by country of residence	A	B	C	D	E	F	G	H	Total
Malaysia	Singapore	21	14	19	1	2	4	26	32	119
Singapore	Thailand	3	4	6	3	-	-	11	-	27
Indonesia	Malaysia	2	2	7	-	-	1	3	4	19
Philippines	Singapore	6	2	1	-	-	-	2	2	13
Malaysia	Thailand	4	1	1	-	-	-	1	-	7

Malaysia	Philippines	1	-	1	-	-	-	-	3	5
Indonesia	Singapore	3	1	5	1	1	-	3	4	18
Indonesia	Philippines	-	-	2	-	-	-	-	1	3
Myanmar	Singapore	-	-	1	-	-	-	-	2	3
Brunei D.	Malaysia	-	-	-	-	2	-	-	-	2
Indonesia	Thailand	1	1	1	-	-	-	1	-	4
Laos	Thailand	-	1	-	-	-	-	1	-	2
Singapore	Vietnam	-	-	-	-	-	1	-	-	1
Thailand	Vietnam	-	1	-	-	-	-	-	-	1
Total		41	27	44	5	5	6	48	48	224

Table 32: Bilateral cooperation between ASEAN countries incommon PCT-patent applications by IPC sections, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). BRICS: Links between China, Brazil, India and South Africa exits. Source: EPO, 2014

While for 'A' patents the second most important tie is observed between Singapore and Lao PDR and the third one between Singapore and Indonesia, the second and third strongest connections for 'W' patents exist between Singapore and Thailand and Indonesia and Malaysia, respectively.

The cooperation patterns between ASEAN countries and other countries or regions for 'W' patent applications are displayed in Table 33. The highest cooperation activities are observed for cooperation between ASEAN and US and ASEAN and European inventors. For both ties more than 1,600 collaborative patent applications are recorded. The collaborative patent activity between ASEAN and Japan and between ASEAN and BRICS-based inventors is on a lower level with around 400 and 500 'W' patent applications, respectively.

Cooperation partner A by country of residence	Cooperation partner B by country of residence	A	B	C	D	E	F	G	H	Total
ASEAN	**BRICS**	117	74	126	8	11	23	82	97	538
ASEAN	**US**	331	200	355	15	66	38	336	355	1,696
ASEAN	**Japan**	56	57	113	3	9	8	93	78	417
ASEAN	**EU28**	292	195	472	60	56	58	226	253	1,612

Table 33: Cooperation patterns between ASEAN countries and other world regions in PCT-patents by IPC sections, 2003-2013[16]. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). BRICS: Links between China, Brazil, India and South Africa exits. Source: EPO, 2014

As described for the bilateral cooperation within the ASEAN region, the cooperation with the four regions above is also not as concentrated on G (physics) and H (electricity) for PCT-patents as it is for 'A' patents. On the contrary, the highest number of collaborative patents with those regions has been filed under IPC section C (chemistry; metallurgy). The numbers for patent applications under the sections A (human necessities), C (chemistry; metallurgy) G (physics) and H (electricity) account for around 20% of all ties each. The distribution between these sections does not vary significantly between the cooperation partners.

[16] Table 33 includes double counting and actual numbers might differ. For example a patent between one inventor based in Singapore and two colleagues living in Germany and France is counted as two links between ASEAN and EU28.

Looking at ASEAN-BRICS cooperation in greater detail, half of the collaborative patent activities (281) between these regions are attributed to the cooperation of Singapore and China. With regard to the IPC classification, the cooperation between the two countries is strongest in sections C (chemistry; metallurgy), H (electricity) and A (human necessities). Other strong ties exist between Singapore and India (68) and between China and Malaysia (55). Again, PCT-patents are more evenly distributed to the IPC-sections than 'A' patents. Looking at the cooperation between ASEAN and BRICS countries, the sections A (human necessities) and C (chemistry; metallurgy) are even a little more important than sections G (physics) and H (electricity).

The cooperation between ASEAN and the US is also dominated by the tie between Singapore and the United States with more than 60% of all observed connections involving these two countries. Other countries with strong ties to the US are Malaysia, Thailand and the Philippines. As described for other PCT-co-inventions, the distribution of patents between the IPC sections is more evenly distributed than for 'A' patents. Most patents are observed in sections A (human necessities), C (chemistry; metallurgy), G (physics) and H (electricity).

More than half of the connections between the ASEAN region and Japan exist between Singapore and Japan. Collaborative patenting between Thailand and Japan accounts for another quarter of all patent applications between those two regions. The IPC-sections with most collaborative patents for this cooperation pair are noticeable in sections C (chemistry; metallurgy) and G (physics).

The collaborative patenting ties between ASEAN and European countries are strongest between Singapore and Germany, the United Kingdom and the Netherlands as well as between Germany and Malaysia, France and Singapore and the United Kingdom and Malaysia. Around 30% of all collaborative patent applications are attributed to section C (chemistry; metallurgy) and between 14% and 18% of the application fall under sections A (human necessities), G (physics) and H (electricity).

Analogous to 'A' patents, the cooperation patterns for 'W' patent applications are also analysed based on the technology field classification. Also, analogous to the section covering 'A' patent applications, it has to be mentioned that a patent can be attributed to more than one technology field and therefore that total numbers presented in Table 34 might differ from the actual patent activity. Additionally, the aggregation of single countries into regions is another source of bias as patent applications between more than two countries are counted multiple times. Nevertheless, the following table provides an overview over cooperation patterns between the ASEAN region and other regions by technological fields.

Technology field	Bilateral ASEAN	United States	Japan	BRICS	EU28	Total
Electrical machinery, apparatus, energy	9	87	17	32	57	202
Audio-visual technology	11	77	50	16	54	208
Telecommunications	8	41	14	9	23	95
Digital communication	6	64	22	23	67	182
Basic communication processes	-	15	6	3	8	32
Computer technology	**10**	**129**	**25**	**34**	**84**	**282**
IT methods for management	13	40	4	17	30	104
Semiconductors	**21**	**156**	**17**	**31**	**84**	**309**

Optics	10	70	20	13	28	141
Measurement	7	51	10	12	46	126
Analysis of biological materials	6	43	13	8	34	104
Control	1	24	1	1	16	43
Medical technology	17	106	7	26	67	223
Organic fine chemistry	**3**	**96**	**26**	**44**	**149**	**318**
Biotechnology	**10**	**112**	**36**	**29**	**91**	**278**
Pharmaceuticals	**13**	**133**	**24**	**41**	**125**	**336**
Macromolecular chemistry, polymers	**13**	**63**	**34**	**38**	**133**	**281**
Food chemistry	6	35	10	19	46	116
Basic materials chemistry	**16**	**108**	**23**	**37**	**157**	**341**
Materials, metallurgy	1	20	16	12	32	81
Surface technology, coating	4	34	13	18	36	105
Micro-structural and nano-technology	2	18	1	5	6	32
Chemical engineering	9	78	9	31	77	204
Environmental technology	3	32	9	9	26	79
Handling	4	23	10	8	34	79
Machine tools	4	12	7	7	24	54
Engines, pumps, turbines	2	6	1	4	23	36
Textile and paper machines	6	34	4	12	29	85
Other special machines	7	49	22	20	65	163
Thermal processes and apparatus	1	12	3	5	17	38
Mechanical elements	-	6	3	7	5	21
Transport	1	12	11	3	25	52
Furniture, games	3	20	2	7	7	39
Other consumer goods	7	39	5	4	57	112
Civil engineering	5	66	9	11	56	147

Table 34: Co-inventions between ASEAN and other regions for 'W' patent applications by technology fields, 2003-2013. BRICS: Links between China, Brazil, India and South Africa exits. Source: EPO, 2014

Most collaborative 'W' patent applications by technology field with ASEAN inventors have been developed in cooperation with US and European-based co-inventors. The bilateral cooperation ties with ASEAN are the least pronounced pattern for 'W' patent applications.

The most 'W' patent applications that are a result of bilateral cooperation within the ASEAN region are attributed to the technology fields semiconductors, basic materials chemistry, macromolecular chemistry, polymers and pharmaceuticals. Cooperation between ASEAN and Japan-based inventors resulted most often in patent applications in the fields of audio-visual technology, biotechnology, macromolecular chemistry, polymers, organic fine chemistry and computer technology. The cooperation with inventors based in BRICS countries is most important in the technology fields organic fine chemistry, pharmaceuticals, macromolecular chemistry, polymers, basic materials chemistry, computer technology, electrical machinery, apparatus, energy and chemical engineering.

The most important cooperation patterns observed are the collaborative co-inventions between ASEAN and US-based inventors. Development processes that involved partners from these countries resulted in a total of more than 1,300 'W' co-inventions that are classified in more than 1,900 technology fields. Most important technology fields are semiconductors, pharmaceuticals, computer technology, biotechnology, basic materials chemistry and medical technology. Second most important cooperation pattern is the link between ASEAN and European countries, for this tie a total of nearly 1,300 'W' patents are recorded which account for more than 1,800 entries per technology field. The cooperation between those two regions is most important in the technology fields basic

materials chemistry, organic fine chemistry, macromolecular chemistry, polymers, pharmaceuticals, biotechnology and computer technology.

In this section, the patent activity of ASEAN-based inventors has been scrutinised. During the years 2003-2013, ASEAN-based inventors developed more than 12,000 'A' and more than 10,000 'W' patent applications. The most inventors filing patent applications are either living in Singapore or Malaysia. The annual output is increasing for the region as such but regional differences exist. For example the output of Vietnam is growing extremely fast from a rather low baseline while Malaysia's 'A' patent application output is decreasing, which could be caused by a reporting problem. Additionally, the growth rates observable for 'W' patent applications exceed those of 'A' applications. ASEAN-based inventors not necessarily file their patent applications at ASEAN authorities. In fact, most inventors file 'A' patent applications in the United States. This could have legal or economic reasons or, to some extent, be the home country of colleagues that were involved in the development of these applications. In contrast to this situation, most 'W' patent applications that are filed at ASEAN authorities and European IPOs are much more important for these applications than for 'A' applications.

Technology-wise, the regions knowledge production is highly specialised for 'A' patent applications, while 'W' patent applications do not show such a clear focus. Most 'A' applications represent technologies needed for the production of semiconductors, computer technology, audio-visual technology, electoral machinery, apparatus, energy, measurement, and telecommunications. 'W' applications most often are technologies for computer technology, audio-visual technology, semiconductors, medical technology and biotechnology.

Co-inventions, applications with more than one inventor, represent knowledge flows between different people, companies and possible regions. During the years 2003-2013 ASEAN-based inventors collaboratively developed 3,500 'A' and 'W' patent applications respectively. When the result of a collaborative research process is an 'A' patent application, the most partners are based in the United States. Partners in European, Asian or ASEAN countries are less important. If the invention is getting filed as a 'W' patent application, the most important partners are based in United States and Europe. Technology-wise, partners from the US are most important for the development of 'A' applications in semiconductors and computer technology. European partners are important for semiconductors and audio-visual technology. For 'W' patent applications, partners from the US are most important in the development of semiconductors, pharmaceuticals and computer technology. European partners are most often involved in the development of technology in the fields of basic materials chemistry, organic fine chemistry and macromolecular chemistry and polymers. After the analysis of patent applications developed by ASEAN-based inventors, the next section focuses on the applicants, owners of the patents.

3.4. Patent activities by ASEAN applicants

In this section, the ASEAN patent activity is analysed on basis of applicant data. The applicant is a person or legal entity how files a patent application. In most cases, the applicant is an enterprise. Additionally, the applicant owns the patent if it is granted. In this chapter the main applicants for ASEAN inventions are identified, the concentration of patent applications on applicant level is analysed, the domestic and foreign ownership of ASEAN inventions is discussed and the technological profile is scrutinised.

3.4.1. Most important applicants and technological specialisation

During the period 2003-2013 ASEAN, applicants filed a total of nearly 26,000 'A' patent applications. With more than 90%, the vast majority of these applications are filed by firms (and individuals) based in Singapore and Malaysia (see Table 35). With more than 1,100 applications, Thai applicants account for the third most filings. The ASEAN-based companies also filed nearly 13,000 'W' patent applications. Nearly 91% of those applications can be attributed to entities based in Singapore or Malaysia, which indicates once again the importance of these two countries for the regional knowledge production (see Table 36).

Country by applicant address	Applications with any inventors	Applications with ASEAN inventors	Applications with domestic inventors	Share of applications with ASEAN inventors	Share of applications with domestic inventors
Brunei Darussalam	155	35	35	22.6%	22.6%
Indonesia	215	190	190	88.4%	88.4%
Cambodia	4	3	3	75.0%	75.0%
Lao PDR	5	1	1	20.0%	20.0%
Myanmar	6	3	3	50.0%	50.0%
Malaysia	4,810	4,430	4,414	92.1%	91.8%
Philippines	686	641	636	93.4%	92.7%
Singapore	18,624	10,935	10,034	58.7%	53.9%
Thailand	1,143	1,046	1,037	91.5%	90.7%
Vietnam	123	99	99	80.5%	80.5%

Table 35: Numbers of 'A' applications form ASEAN applicants per country, first filings, 2003-2013. EPO PATSTAT online, 2016

In the table above, the number and shares of 'A' patent applications from ASEAN-based applicants in total, applications with the involvement of ASEAN inventors and applications with domestic inventors are depicted. On the regional average around two thirds of the applications are developed at least in cooperation with ASEAN inventors. The numbers for the involvement of domestic inventors are slightly below this share but still around 64% of all 'A' patent applications. On country level, most applications without ASEAN inventors are filed by applicants based in Lao PDR, Brunei Darussalam, Myanmar and Singapore. Especially Singapore is experiencing a high inflow of knowledge developed outside of the region, which indicates the relevance of the city state as knowledge hub and the economic power of local companies. In contrast, Malaysia, as the country with the second most applications on applicant level, has an inflow of just a few hundred 'A' patent applications developed by inventors outside of the country. For all countries in the ASEAN region, the shares of 'A' patent applications from domestic and ASEAN-based inventors are very similar, which indicates that if an invention from a foreign inventor is filed from an ASEAN applicant, the inventor is most likely not living in an ASEAN state.

Country by applicant address	Applications with any inventors	Applications with ASEAN inventors	Applications with domestic inventors	Share of applications with ASEAN inventors	Share of applications with domestic inventors
Brunei Darussalam	17	9	9	52.9%	52.9%
Indonesia	272	250	249	91.9%	91.5%

Cambodia	3	3	2	100.0%	66.7%
Lao PDR	28	14	14	50.0%	50.0%
Myanmar	4	4	4	100.0%	100.0%
Malaysia	2,717	2,585	2,575	95.1%	94.8%
Philippines	456	435	434	95.4%	95.2%
Singapore	8,435	7,162	6,948	84.9%	82.4%
Thailand	752	709	709	94.3%	94.3%
Vietnam	175	167	167	95.4%	95.4%

Table 36: Numbers of 'W' applications form ASEAN applicants per country, 2003-2013. EPO, 2014

The situation for 'W' patent applications from ASEAN-based applicants is depicted in Table 36. ASEAN applicants filed a total of nearly 13,000 'W' patent applications during the period 2003-2013. Most of these applications can be attributed to Singaporean and Malaysian applicants. The two countries account for nearly 87% of all ASEAN applications on applicant level whereby Singaporean applicants alone are already responsible for two thirds of these applications.

Most PCT applications in ASEAN countries involve ASEAN-based domestic inventors. Only Lao PDR, Brunei Darussalam and Singapore have sizeable (above 10%) shares of PCT applications that do not involve domestic or ASEAN inventors. These applications can be seen as indicating knowledge inflow: ASEAN applicants acquiring knowledge developed elsewhere. In absolute numbers, Singapore is the only country with a significant knowledge gain through incoming patent applications. The differences between total number of patent applications and applications with ASEAN-based inventors, is less pronounced for 'W' then for 'A' patent applications, which can be explained by the fact that 'W' patents potentially provide global protection. The difference between applications with ASEAN-based inventors and domestic inventors is very small, which indicates that if foreign inventors are involved in the development of this patent application, they are most likely living outside the ASEAN region.

For the sake of identifying the most important applicants and to calculate the concentration of patent applications on applicants, the data on single applicant level retrieved from EPOs PATSTAT has been cleaned manually. For example if an applicant, who is identified by an ID and by name, obviously has different entries in the database, like different IDs but the same or a very similar name (e.g. capital letters, with or without Ltd. etc.), the results have been aggregated. In some cases also the inventors are applicants for their own invention. However, the data cleaning effort necessary to disambiguate inventor name data is beyond the scope of this study. Therefore, inventors who are applicants for their own invention are excluded from the following analysis of concentration and most important applicants.

In the cleaned dataset for 'A' applications a total of 1,100 different applicants has been identified (see Table 37). The Top-100 applicants account for more than 6,000 applications which means that 81% of all applications from ASEAN applicants is filed by this small group of most active entities. The 1,000 most active applicants together file 98% of all applications in the ASEAN region.

	Applications	Mean applications by applicant	Share of all applications
100 Top applicants	6,471	64.7	81%
1.000 Top applicants	7,825	7.8	98%
All applicants (>1,100)	7,967	7.0	

Table 37: Total and mean values of 'A' patent applications for all, Top-100 and Top-1.000 ASEAN applicants, 2003-2013. EPO, 2014

On average, members form the Top-100 group filed more than 64.7, members form the Top-1,000 group filed around 7.8 and the average ASEAN applicant filed 7.0 'A' patent applications during the period 2003-2013. As it is notable from this data, the patent activity on applicant level is heavily concentrated in a group of companies. Therefore, the next step is to identify the most active ASEAN firms, the results of this analysis for 'A' patent applications can be found in Table 38.

Rank	Applicant's name	Country of location	No. of applications
1	Avago Pte. Ltd.	Singapore	1,607
2	STATS ChipPAC, Ltd.	Singapore	1,078
3	Lenovo Pte. Ltd.	Singapore	513
4	Siemens Medical Instruments Pte. Ltd.	Singapore	413
5	Chartered Semiconductor Manufacturing Ltd.	Singapore	342
6	Globalfoundries Singapore Pte, Lte.	Singapore	249
7	Agency for Sceince, Technology and Reasearch	Singapore	219
8	STMicroelectronics Pte Ltd.	Singapore	187
9	Creative Technology Ltd	Singapore	137
10	Universiti Teknologi Malaysia	Malaysia	98

Table 38: Top-10 applicants filing 'A' patent applications of ASEAN inventors, 2003-2013. EPO, 2014

Nine of the Top-10 applicants for 'A' patent applications from the ASEAN region are based in Singapore and only the Universiti Teknologi Malaysia is among those Top-applicants. On average, one of these institutions filed more than 480 applications during the period 2003-2013. By far the most applications are filed by Avago Technologies and STATS ChipPAC Limited. Both companies produce semiconductors.

More than 1,600 different ASEAN applicants filing 'W' patent applications have been identified for the period 2003-2013 (see Table 39). These applicants accounted for more than 7,000 'W' patent applications. The Top-100 group of the most active applicants is responsible for more than 4,800 applications which correspond to 65% of all applications. The group of the Top-1,000 applicants filed more than 6,700 'W' patent applications and were involved in 91% of all applications. On average, the 100 most active applicants produced 48.5 applications, the Top-1,000 accounted for 6.7 patent applications and all applicants filed 4.4 'W' patent applications on average.

	Applications	Mean applications by applicant	Share of all applications
100 Top applicants	4,805	48.5	65%
1.000 Top applicants	6,702	6.7	91%
All applicants (>1,600)	7,362	4.4	

Table 39: Total and mean values of 'W' patent applications for all, Top-100 and Top-1.000 ASEAN applicants, 2003-2013. EPO, 2014

The Top-10 group of the most productive applicants in the ASEAN region for 'W' patent applications consists of eight Singaporean and two Malaysian organisations (see Table 40). On average, each of these ten applicants accounts for more than 300 'W' patent applications. The by far most important ASEAN applicant for 'W' patent applications is the Singaporean Agency for Science, Technology and Research (A*STAR) with more than 1,200 applications. It is noteworthy that A*STAR and Creative Technology Ltd. are the only institutions that are among the Top-10 applicants for 'A' and 'W' patent applications. This indicates that the decision to file an 'A' or 'W' patent is also depending on a firm's strategy.

Rank	Applicant's name	Country of location	No. of applications
1	Agency for Science, Technology & Research	Singapore	1,262
2	MIMOS Berhad	Malaysia	506
3	National University of Singapore	Singapore	465
4	Nanyang Technological University	Singapore	304
5	Creative Technology LTD	Singapore	186
6	MediaTek Singapore Pte. Ltd.	Singapore	139
7	Universiti Putra Malaysia	Malaysia	99
8	Nanyang Polytechnic	Singapore	98
9	DH Technologies Development Pte. Ltd.	Singapore	92
10	Universiti Sains Malaysia	Malaysia	89

Table 40: Top-10 applicants filing 'W' patent applications of ASEAN inventors, 2003-2013. EPO, 2014

Technological specialisation according to the country of origin of an applicant filing the application

Just because a company is based in the ASEAN region and probably is filing mostly inventions from inventors living in ASEAN countries does not necessarily mean that these patent applications are filed at ASEAN patent authorities as well. Additionally, the technological specialisation of the ASEAN applicants is of interest. In the following two tables, this information is combined to illustrate patterns of certain technologies getting filed in specific regions. Like for every analysis on technology fields it has to be stated that even though the number of patent applications represents the region's actual output, some double counting is possible because one patent can be attributed to more than one technology field.

Most of the 'A' patents from ASEAN applicants are attributed to the technology fields semiconductors, computer technology, audio-visual technology, electrical machinery, apparatus, energy and measurement (see Table 41). More than half of the 'A' patent applications from ASEAN applicants get filed at ASEAN authorities, followed by other Asian and US authorities. Technology fields where other patent authorities are most important for 'A' patent application from ASEAN applicants are non-ASEAN-Asian authorities for semiconductors, computer technology, audio-visual technology and electrical machinery, apparatus, energy. The United States Patent and Trademark Office (USPTO) is relevant for patent applications in the fields of semiconductors, computer technology, audio-visual technology and measurement.

Technology field	Applicant from ASEAN, first filing in…						
	ASEAN	Asia	EU28	Non-EU Europe	North and Middle America (without the US)	Oceania	United States
Electrical machinery, apparatus, energy	600	196	86	0	8	2	129
Audio-visual technology	684	232	127	0	20	3	256
Telecommunications	259	149	46	1	6	0	77
Digital communication	194	114	37	3	2	0	65
Basic communication processes	260	63	28	0	25	0	105
Computer technology	1,052	361	76	47	45	3	364
IT methods for management	121	20	17	2	1	0	26
Semiconductors	2,437	378	109	1	12	4	588
Optics	233	91	22	4	2	0	58
Measurement	490	130	53	7	12	0	152
Analysis of biological materials	33	22	11	0	0	0	11
Control	163	75	28	1	7	1	45
Medical technology	201	44	40	4	0	1	39
Organic fine chemistry	122	64	29	4	8	0	38
Biotechnology	135	76	12	2	0	1	18
Pharmaceuticals	103	79	17	1	3	1	16
Macromolecular chemistry, polymers	74	50	34	3	9	0	22
Food chemistry	91	26	12	10	0	0	37
Basic materials chemistry	132	26	28	6	2	0	37
Materials, metallurgy	73	52	19	3	1	1	18
Surface technology, coating	201	41	17	5	2	0	56
Micro-structural and nano-technology	36	59	6	1	2	0	9
Chemical engineering	186	60	28	3	3	0	40
Environmental technology	66	34	11	0	4	0	10
Handling	136	15	17	5	4	0	50
Machine tools	193	29	71	1	3	0	74
Engines, pumps, turbines	62	7	30	0	0	0	9
Textile and paper machines	101	26	19	1	2	4	55
Other special machines	187	38	26	2	1	1	44
Thermal processes and apparatus	49	28	10	1	0	0	6
Mechanical elements	96	25	13	3	4	0	21
Transport	86	36	13	2	1	3	8
Furniture, games	150	10	8	0	6	2	36
Other consumer goods	150	13	11	1	3	1	27
Civil engineering	206	20	26	3	6	0	45

Table 41: Applicants filing ASEAN 'A' inventions by country of origin and technology field, 2003-2013. EPO, 2014

The technology fields with most 'W' patent applications from ASEAN-based applicants are computer technology, semiconductors, audio-visual technology, biotechnology, medical technology, pharmaceuticals and digital communication (see Table 42). ASEAN applicants file around 80% of all the 'W' patent applications per technology field at ASEAN authorities. As 'W' patents potentially ensure global protection, there is no need to file abroad. If they are filed at a foreign patent authority they are most often filed at a European patent authority. The technology fields that are the most important for these applications are civil engineering, audio-visual technology, basic materials chemistry, computer technology and semiconductors. Technology fields for which the US authority is an important option are semiconductors and computer technology.

Technology field	Applicant from ASEAN, first filing in…						
	ASEAN	Asia	EU	Non-EU Europe	North and Middle America (without the US)	Oceania	United States
Electrical machinery, apparatus, energy	658	36	65	1	10	3	75
Audio-visual technology	782	48	149	2			61
Telecommunications	528	11	48	6	2	2	67
Digital communication	735	18	57	5	1	3	45
Basic communication processes	174	8	31	3	7		12
Computer technology	1,283	36	110	5	7	2	128
IT methods for management	388	14	37	1	1	5	37
Semiconductors	845	31	91	2	4	2	125
Optics	360	30	21			2	27
Measurement	602	25	60	9	11	3	29
Analysis of biological materials	325	10	20	5		1	8
Control	301	5	23	1	3	2	15
Medical technology	767	22	52	2	1	9	60
Organic fine chemistry	510	59	69	11	3	5	41
Biotechnology	793	19	42	7	1	13	39
Pharmaceuticals	749	15	58	17	3	11	35
Macromolecular chemistry, polymers	436	26	50	12	2	5	17
Food chemistry	264	15	32	27		1	15
Basic materials chemistry	564	30	116	9	15	8	41
Materials, metallurgy	253	9	13	1	1	2	8
Surface technology, coating	277	16	17	2		4	21
Micro-structural and nano-technology	223	2	2				6
Chemical engineering	548	17	38	8	2	11	36
Environmental technology	236	10	17	2	1	3	15
Handling	308	17	26	12	2	4	19
Machine tools	207	8	33	2	2	2	19
Engines, pumps, turbines	247	9	62		1	4	6
Textile and paper machines	160	11	21	4		2	21
Other special machines	445	21	37	10	2	7	22
Thermal processes and apparatus	157	4	23			2	9
Mechanical elements	169	8	20	2	3	4	12
Transport	249	8	13	6	2	4	9
Furniture, games	278	8	20	4	1	4	10
Other consumer goods	346	12	70	8		9	17
Civil engineering	474	22	159	13	49	13	40

Table 42: Applicants filing ASEAN 'W' inventions by country of origin and technology field, 2003-2013. EPO, 2014

The analysis in this section shows that there is a set of highly active institutions filing the vast majority of patent applications developed by ASEAN-based inventors. The 100 institutions filing the most applications account for 81% of all 'A' and 65% of all 'W' patent applications. Most of these actors are based in Singapore or Malaysia. These applicants not only file inventions developed by ASEAN-based inventors but also form inventors abroad. The ASEAN applicants file most of their inventions at ASEAN patent authorities but for 'A' patents the US and Asian authorities are an alternative option. The European authorities are playing a role in 'W' patent applications. Technology-wise, the ASEAN applicants are filing patent applications in the fields of semiconductors, computer technology, audio-visual technology, electrical machinery, apparatus, energy,

measurement, biotechnology, medical technology, pharmaceuticals and digital communication. In a next step the ownership of patent applications developed by ASEAN inventors is scrutinised.

3.4.2. Domestic and foreign ownership of ASEAN inventions

The ownership of patents is an important indicator for knowledge flows. Patent applications that are developed in a region and owned by an applicant in another region represent an outflow of knowledge and vice versa. This is important as knowledge tends to accumulate in some regions and because patents represent potential revenue. Therefore, in this subchapter the knowledge flows of inventions developed by ASEAN-based inventors are scrutinised. In these analyses we do not distinguish between patent with a single owner and shared patent applications. The results must be interpreted as patent applications with at least one ASEAN-based applicant for domestic ownership and as patent applications with at least one ASEAN-based inventor with at least one foreign applicant for foreign ownershipt. Therefore the shares for foreign and domestic ownership do not add up to 100%.

Most of the 'A' patents developed by inventors living in ASEAN countries are also filed by an applicant with an ASEAN address (see Table 43). More than 50% of all these patents are owned domestically (there might also be foreign owners, but there is at least one domestic inventor and owner). Singapore is important not only from inventor's side but also a lot of applicants are registered in the city-state. Malaysian inventors with an applicant based in Singapore are the sixth most common inventor-applicant pair in the ASEAN region and the third most important combination for Malaysia.

Rank	Inventor by country of residence	Applicant by country of address	Sum of applications
1	Singapore	Singapore	4,362
2	Malaysia	Malaysia	2,294
3	Singapore	United States	952
4	Malaysia	United States	716
5	Malaysia	Taiwan	605
6	Malaysia	Singapore	456
7	Vietnam	Korea	427
8	Thailand	Thailand	362
9	Philippines	Philippines	275
10	Singapore	Taiwan	271
22	Indonesia	Indonesia	70
34	Vietnam	Vietnam	30
44	Brunei Darussalam	Brunei Darussalam	23
123	Cambodia	Cambodia	2
149	Lao PDR	Lao PDR	1
149	Myanmar	Myanmar	1

Table 43: Ownership of ASEAN 'A' patents by country of inventor and applicant, 2003-2013. EPO, 2014

Most extra-regional applicants of 'A' patents with the contribution of ASEAN inventors are registered in the US. 14% of all patents with ASEAN inventors have an US-based applicant. The second most important group of non-ASEAN applicants, with 13% of all applications, are based in Asian countries that are not part of the ASEAN region, followed by applicants based in Europe with a share of 6% of

all applications. Taiwan and Korea are the most important applicant home countries for Asian applications. Germany is the most important country from Europe.

A little less than three quarters of all PCT applications are owned domestically within the ASEAN region (see Table 44). For most ASEAN countries, the most common scenario is that inventors and applicants are both from the same country (at least one from each). In contrast to 'A' patents, the most important non-ASEAN applicants are based in countries of the European Union. 9% of all patents with at least one ASEAN inventor have applicants in the EU. The most common inventor-applicant pairs with European applicants are observed between Singapore and the EU as well as between Malaysia and the EU.

Rank	Inventor by country of residence	Applicant by country of residence	Sum of applications
1	Singapore	Singapore	6,525
2	Malaysia	Malaysia	2,360
3	Singapore	EU	703
4	Thailand	Thailand	634
5	Singapore	United States	481
6	Philippines	Philippines	417
7	Malaysia	EU	279
8	Singapore	Asia	260
9	Indonesia	Indonesia	226
10	Malaysia	United States	222
12	Vietnam	Vietnam	148
39	Lao PDR	Lao PDR	10
47	Brunei Darussalam	Brunei Darussalam	7
59	Myanmar	Myanmar	3
68	Cambodia	Cambodia	2

Table 44: Ownership of ASEAN 'W' patents by country of inventor and applicant, 2003-2013. EPO, 2014

The most European applicants have addresses in the Netherlands, Germany or the United Kingdom. Another 6% of all PCT-patent applications have an applicant from the United States and applicants from Asian countries account for 3%. Overall, PCT patents with the contribution of inventors living in ASEAN countries are much very likely to also have an ASEAN-based applicant.

Country	Sum of applications by residence of inventor*	Sum of applications by applicant's address**	Sum of applications with domestic inventor and applicant	Share of domestically owned applications
Brunei Darussalam	25	23	23	92%
Indonesia	341	80	70	21%
Cambodia	8	2	2	25%
Laos	4	1	1	25%
Myanmar	38	1	1	3%
Malaysia	4,179	2,338	2,294	55%
Philippines	556	286	275	49%
Singapore	6,042	4,857	4,362	72%
Thailand	632	393	362	57%
Vietnam	525	30	30	6%

Table 45: Domestically owned 'A' patents with ASEAN inventors as shares of all applications, 2003-2013. Note: * Due to co-ownership the numbers of patent applications by inventors for this analysis is higher than the actual numbers. ** Values only represent applications with the involvement of ASEAN-based inventors. EPO, 2014

As described in Table 45, the regional average for patents developed with the involvement of ASEAN inventors and applicants from the same country is higher than 50%. Singapore with 72%, Thailand with 57% and Brunei Darussalam with 92%, but rather small total patent activity, are the only countries above the regions average share. With intermediate patent activity, the domestic ownership with only 6% is very low for Vietnam. In comparison to 'W' patent applications, the domestic ownership of 'A' patents is much lower.

Country	Sum of applications by residence of inventor	Sum of applications by applicant's address*	Sum of applications with domestic inventor and applicant	Share of domestically owned applications
Brunei Darussalam	7	9	7	100%
Indonesia	248	237	226	91%
Cambodia	3	3	2	67%
Laos	11	11	10	91%
Myanmar	4	3	3	75%
Malaysia	2,430	2,403	2,360	97%
Philippines	439	428	417	95%
Singapore	6,703	6,787	6,525	97%
Thailand	671	650	634	94%
Vietnam	154	148	148	96%

Table 46: Domestically owned PCT-patents with ASEAN inventors as shares of all applications, 2003-2013. Note: * Values only represent applications with the involvement of ASEAN-based inventors. EPO, 2014

On the regional average, 97% of all 'W' patent applications are owned by domestic applicants (see Table 46). The share of domestically owned 'W' patent applications is above 90% in all ASEAN countries with the exception of Myanmar where only three out of four patent applications are owned domestically. The highest shares are observable in Brunei Darussalam, Malaysia, Singapore and Vietnam. The outflow of knowledge as measured by 'W' patent applications generated in ASEAN countries is rather low. This can either be interpreted as a situation where ASEAN companies are capable of making use of the local knowledge base or that the locally produced knowledge is not meeting a global demand. Keeping the region's dynamic economic development in mind, first explanation seems to be more likely.

Foreign ownership

Foreign patent ownership in this analysis is defined as a patent application with an inventor from an ASEAN country and at least one applicant not based in the same ASEAN country. The data retrieved from EPOs PATSTAT is processed to display foreign owned 'A' and 'W' patent applications by IPC section and region of the foreign applicant as well as foreign owned patent applications by technology field and ASEAN country. It has to be mentioned that a single patent can be attributed to more than a single IPC section and therefore double counting is possible.

The results on IPC level are depicted in Table 47. The highest counts for 'A' patents with inventors living in ASEAN countries and at least one foreign applicant are filed in sections H (electricity) with more than 2,600 applications and G (physics) with 2,100 applications. More than 500 patent

applications are filed under sections B (performing operations; transporting) and C (chemistry; metallurgy).

Foreign applicants by regions and IPC technology section	A	B	C	D	E	F	G	H
Africa	1	1	1	0	0	0	0	18
Antarctica	0	0	0	0	0	0	0	0
ASEAN	24	34	9	2	3	77	289	324
Asia	175	251	262	11	20	71	724	956
EU	91	151	116	14	26	64	224	342
Non-EU Europe	18	14	14	1	3	4	60	6
North and Middle America (without the US)	10	11	18	1	6	4	80	54
Oceania	4	8	2	0	0	1	6	5
South America	0	0	0	0	1	0	4	0
United States	136	278	119	4	45	43	720	956
Share of foreign owned patents by section	40.2%	44.4%	49.1%	48.5%	33.2%	48.6%	51.9%	42.6%

Table 47: Foreign ownership of 'A' patents by IPC-sections, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

Most of the foreign applicants are registered in the non-ASEAN Asian countries, United States and in member states of the European Union. The number of ASEAN inventions that are owned in another ASEAN country represents around 5% of all foreign own patent applications per IPC section. High numbers of inner-regional foreign ownership are especially seen in sections H (electricity) and G (physics) with around 700 and 950 applications. Overall, the foreign ownership shares for 'A' patents are higher than for 'W' patents with ASEAN inventors. The highest foreign ownership shares are noticeable in sections G (physics), C (chemistry; metallurgy), F (mechanical engineering; lighting; heating; weapons; blasting) and D (textiles; paper) with values around 50% of all applications in these sections. The lowest share of foreign owned patents is observed in section E (fixed constructions) with 33% of all application. So the variation between the technological sections is not as distinct for 'A' patents as it is for 'W' patents.

Foreign applicants by regions and IPC technology section	A	B	C	D	E	F	G	H
Africa	4	3	3		1		2	11
ASEAN	83	56	54	9	21	16	92	87
Asia	109	74	104	6	22	16	144	100
EU	217	143	231	56	159	108	311	330
Non-EU Europe	57	30	37	3	13	2	20	16
North and Middle America (without the US)	6	9	20		49	3	21	23
Oceania	31	26	30	2	13	9	15	10
South America	3		1			3	3	2
United States	143	127	114	5	40	32	242	335
Share of foreign owned patents by section	28.5%	26.3%	25.0%	46.8%	66.7%	28.0%	27.6%	31.0%

Table 48: Foreign ownership of PCT-patents by IPC-sections, 2003-2013. Sections of the IPC-classification: A (human necessities); B (performing operations; transporting); C (chemistry; metallurgy); D (textiles; paper); E (fixed

constructions); F (mechanical engineering; lighting; heating; weapons; blasting); G (physics); H (electricity). Source: EPO, 2014

The highest total numbers for ´W´ patents developed with at least one ASEAN inventor that was filed by at least one foreign applicant are observable in sections G (physics), H (electricity) and A (human necessities) (see Table 48). The most foreign applicants are based in the European Union, the United Stated, and non-ASEAN Asian countries. Even though the PCT-patents are more evenly distributed over all IPC sections than 'A' patents, the shares of foreign owned patents by section shows a surprising allocation with the highest shares of foreign owned patent applications in sections E (fixed constructions), D (textiles; paper) and H (electricity). The ASEAN countries overall show rather small patent activity in sections E and D and these patents are owned by foreign applicants above average. Applicants from the EU and the US are most common countries for foreign owned 'W' patent applications.

Most of the foreign owned 'A' patent applications by technology fields are related to technologies for semiconductors and most often, they are developed by inventors from Malaysia and Singapore (see Table 49). Other technology fields with high numbers of foreign owned 'A' applications are computer technology, audio-visual technology, and electrical machinery, apparatus, energy. The countries with the highest total number of foreign owned patent applications are Singapore, Malaysia and Vietnam whereby the share of foreign owned applications is the highest for Vietnam.

Technology fields | Inventor from…	**BN**	**ID**	**KH**	**LA**	**MM**	**MY**	**PH**	**SG**	**TH**	**VN**
Electrical machinery, apparatus, energy	-	18	-	-	11	257	42	181	31	47
Audio-visual technology	-	17	-	-	5	321	24	370	28	26
Telecommunications	-	21	-	-	1	128	5	124	14	44
Digital communication	-	20	-	-	1	80	11	87	9	38
Basic communication processes	-	1	-	-	4	136	-	96	3	20
Computer technology	4	38	-	-	6	465	34	423	30	57
IT methods for management	-	7	-	-	-	20	15	40	5	3
Semiconductors	-	50	-	-	4	636	138	545	18	20
Optics	-	9	1	1	3	119	4	74	13	12
Measurement	-	14	-	-	1	264	12	141	28	36
Analysis of biological materials	-	1	-	-	-	9	4	26	1	13
Control	3	4	-	-	4	33	22	95	10	10
Medical technology	-	3	-	-	-	47	13	67	17	22
Organic fine chemistry	-	15	1	1	1	27	14	55	14	30
Biotechnology	-	12	-	-	1	23	11	35	10	36
Pharmaceuticals	-	6	3	1	-	36	10	30	10	50
Macromolecular chemistry, polymers	-	10	-	-	-	16	7	53	9	31
Food chemistry	-	30	1	-	-	13	3	9	18	18
Basic materials chemistry	-	10	-	-	-	38	3	41	7	23
Materials, metallurgy	-	8	-	1	1	15	2	27	3	39
Surface technology, coating	-	8	-	-	3	44	7	61	11	10
Micro-structural and nano-technology	-	7	-	-	-	31	3	14	1	24
Chemical engineering	-	13	-	1	-	31	13	47	16	29
Environmental technology	-	11	-	-	-	9	7	15	12	10
Handling	-	7	-	-	-	25	12	38	16	5
Machine tools	-	2	-	-	1	98	15	55	13	9
Engines, pumps, turbines	-	-	-	-	-	4	7	38	4	4
Textile and paper machines	-	5	-	-	-	23	7	68	6	11
Other special machines	-	8	-	-	1	36	9	36	20	19

Thermal processes and apparatus	-	-	-	-	-	21	3	19	4	-
Mechanical elements	-	1	-	-	-	29	3	19	8	11
Transport	-	1	-	-	-	31	3	14	12	11
Furniture, games	-	3	1	-	-	24	7	19	20	1
Other consumer goods	-	3	-	-	-	27	6	18	9	4
Civil engineering	-	14	-	-	-	40	2	45	8	1

Table 49: Foreign ownership of 'A' patent applications with ASEAN inventors by technology fields, 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); EPO, 2014; strongest technology fields per country are highlighted

The foreign owned 'W' patent applications most often are related to technologies used in the fields of civil engineering, computer technology, audio-visual technology, semiconductors and basic materials chemistry (see Table 50). The most foreign owned 'W' patent applications are developed by inventors based in Singapore, Malaysia and Thailand. On a disaggregated level, most foreign owned 'W' patent applications in the fields of audio-visual technology, computer technology and semiconductors are developed by inventors based in Singapore. Malaysian inventors are most often involved in the development of foreign owned technologies for civil engineering and basic materials chemistry. Most foreign owned applications from Thai inventors fall in the field of organic fine chemistry.

Technology fields	**BN**	**ID**	**KH**	**LA**	**MM**	**MY**	**PH**	**SG**	**TH**	**VN**
Electrical machinery, apparatus, energy	-	2	-	1	-	38	16	135	6	1
Audio-visual technology	-	-	-	-	-	26	3	229	21	2
Telecommunications	-	1	-	-	-	43	14	88	4	4
Digital communication	-	-	-	-	-	47	23	79	7	4
Basic communication processes	-	-	-	-	-	14	-	46	2	-
Computer technology	-	1	-	-	-	90	15	182	20	2
IT methods for management	-	3	-	-	-	14	22	84	10	-
Semiconductors	-	18	-	-	-	93	40	128	8	-
Optics	-	5	-	-	-	12	6	54	14	1
Measurement	-	11	-	2	-	32	6	66	31	1
Analysis of biological materials	-	2	-	-	-	9	-	32	4	1
Control	2	-	-	-	-	11	8	37	1	1
Medical technology	-	-	-	-	-	52	9	89	14	-
Organic fine chemistry	-	5	-	-	-	11	7	93	76	3
Biotechnology	-	9	1	3	-	15	5	78	19	5
Pharmaceuticals	-	2	3	-	-	25	12	85	42	3
Macromolecular chemistry, polymers	-	4	-	-	-	28	-	75	19	1
Food chemistry	-	8	2	-	-	9	10	51	25	5
Basic materials chemistry	-	24	-	-	2	110	16	73	18	3
Materials, metallurgy	-	1	-	-	-	8	6	14	6	2
Surface technology, coating	-	6	-	-	-	20	1	29	8	3
Micro-structural and nano-technology	-	-	-	-	-	1	1	7	1	-
Chemical engineering	-	3	-	-	-	36	12	57	16	5
Environmental technology	-	4	-	1	-	10	11	22	3	2
Handling	-	4	-	-	-	22	15	38	13	3
Machine tools	-	3	-	-	-	39	4	25	11	-
Engines, pumps, turbines	-	-	-	-	-	9	1	74	1	1
Textile and paper machines	-	10	-	-	-	10	3	37	10	-
Other special machines	-	3	-	3	-	29	3	47	20	4
Thermal processes and apparatus	-	-	-	-	-	5	-	21	15	-
Mechanical elements	-	2	-	-	-	11	2	34	6	1

Transport	-	1	-	1	-	12	1	14	16	2
Furniture, games	-	1	-	-	-	11	5	18	23	4
Other consumer goods	-	14	-	-	-	36	4	53	27	1
Civil engineering	14	43	-	-	-	148	9	75	29	-

Table 50: Foreign ownership of 'W' patent applications by technology fields, 2003-2013. Country codes: SG (Singapore); MY (Malaysia); TH (Thailand); PH (Philippines); ID (Indonesia); VN (Vietnam); LA (Laos); BN (Brunei Darussalam); KH (Cambodia); MM (Myanmar); EPO, 2014; strongest technology fields per country are highlighted

The results presented in the sections about ASEAN applicants can be summarised as follows: ASEAN-based applicants filed around 26,000 'A' and 13,000 'W' patent applications. From these applications, two thirds of the 'A' and nearly 90% of the 'W' applications were at least co-developed by ASEAN-based inventors. Filing an application from ASEAN-based inventors and applicants based in another ASEAN country plays a minor role. Most of the applications are owned by a relatively small number of applicants. The Top-100 applicants own 81% of all 'A' and 65% of all 'W' applications owned by ASEAN-based applicants. The most active applicants are all based either in Singapore or Malaysia. The Top-10 applicant groups for 'A' and 'W' patent applications do only overlap for two companies, the Singaporean Agency for Science, Technology and Research (A*Star) and the Creative Technology Ltd. which is based in Singapore as well. This indicates that the decision to file either an 'A' or a 'W' patent application is highly depending on the institution's strategy.

Most of the 'A' and a huge majority of the 'W' applications of ASEAN-based applicants are getting filed at ASEAN patent authorities. The USPTO plays an important role for 'A' patents while European authorities are often used for filing 'W' applications. Technology-wise the most important fields for ASEAN applicants are semiconductors, computer technology, audio-visual technology for 'A' and 'W' applications. But the technological specialisation on these fields in more pronounced for 'A' than for 'W' applications. For later fields like biotechnology, medical technology or pharmaceutical play a more important role.

The ownership patterns for inventions developed by ASEAN-based inventors are different for 'A' and 'W' applications. While 'A' patents are owned by ASEAN applicants in more than the half of the cases, 'W' applications are owned by ASEAN applicants in three quarters of the cases. Domestic ownership of 'A' applications is the most common situation in Singapore, Malaysia, Thailand, the Philippines, Brunei Darussalam, Cambodia and Lao PDR. Foreign ownership 'A' applications most often have applicants in the United States, Taiwan and Korea. While domestic ownership for 'W' applications is the most common variation for all ASEAN countries, the most common foreign ownership ties between ASEAN and other regions exist between Singapore and the EU, Singapore and the US, Malaysia and the EU as well as between Singapore and non-ASEAN Asian countries. Technology-wise, the most common foreign owned 'A' applications are from the fields semiconductors, computer technology, audio-visual technology, and electrical machinery, apparatus, energy. The highest numbers for foreign owned 'W' patent applications have technologies for civil engineering, computer technology, audio-visual technology, semiconductors and basic materials chemistry.

4. Conclusions

The analysis of the ASEAN patent activity had the following aims. We scrutinised the dynamics, and technological specialisation of the output from ASEAN-based inventors and applicants as well as volume of applications at the ASEAN patent authorities. We identified the main institutional actors filing patent applications developed by ASEAN inventors. Furthermore we aimed to illustrate the knowledge flows between the ASEAN and other world regions. The data basis for this report is the EPO´s PATSTAT Version April 2014 and we used national 'A' patent applications as well as international patent applications 'W' which are filed under the Patent Cooperation Treaty (PCT). The analysis covers the years 2003-2013. The analysis of the patent activity of ASEAN inventors and applicants is based only on first filed 'A' patent applications while analysis of 'W' patent covers all applications. The analysis of the volume of patent applications at ASEAN authorities is also built on all applications but we distinguished between patent families and first filings.

EPO´s PATSTAT covers the patent authorities of Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. There is no data available for Cambodia and Lao PDR. With the exception of Malaysia, all ASEAN patent authorities experience a dynamic development during the period 2003-2013. Whereby the growth of 'W' application is more dynamic than for 'A' applications. Nevertheless, the regional imbalances are obvious. The vast majority of patent applications are filed at authorities in Singapore and Malaysia. Technology-wise, applications at ASEAN authorities show a specialisation in IPC sections physics and electricity. Singapore and Malaysia also see a relevant inflow of patent families developed and first filed by inventors based outside of the region which other countries do not experience.

During the years 2003-2013, ASEAN-based inventors developed more than 12,000 'A' and more than 10,000 'W' patent applications. The most inventors filing patent applications are either living in Singapore or Malaysia. The annual output is increasing for the region as such but regional differences exist. For example, the output of Vietnam is growing extremely fast from a rather low baseline while Malaysia's 'A' patent application output is decreasing, which could be a reporting problem. Additionally, the growth rates observable for 'W' patent applications exceed those of 'A' applications. ASEAN-based inventors not necessarily file their patent applications at ASEAN authorities. In fact, most inventors file 'A' patent applications in the United States. This could have legal or economic reasons or, to some extent, be the home country of colleagues that where involved in the development of these applications. In contrast to this situation, most 'W' patent applications are filed at ASEAN authorities and European IPOs are much more important for these applications than for 'A' application.

Technology-wise, the regions knowledge production is highly specialised in 'A' patent applications while 'W' patent applications do not show such a clear focus. Most 'A' applications represent technologies needed for the production of semiconductors, computer technology, audio-visual technology, electoral machinery, apparatus, energy, measurement, and telecommunications. 'W' applications most often are technologies for computer technology, audio-visual technology, semiconductors, medical technology and biotechnology.

Co-inventions, applications with more than one inventor, represent knowledge flows between different people, companies and possible regions. During the years 2003-2013, ASEAN-based inventors collaboratively developed 3,500 'A' and 'W' patent applications respectively. When the result of a collaborative research process is an 'A' patent application, partners are most frequently based in the United States. Partners in European, Asian or ASEAN countries are less important. If the invention is getting filed as a 'W' patent application, the most important partners are based in the United States and Europe. Technology-wise, partners from the US are most important for the development of 'A' applications for semiconductors and computer technology. European partners are important for semiconductors and audio-visual technology. For 'W' patent applications, partners from the US are most important in the development of semiconductors, pharmaceuticals and computer technology. European partners are most often involved in the development of technology in the fields of basic materials chemistry, organic fine chemistry and macromolecular chemistry and polymers.

The analysis of ASEAN applicants shows that there is a set of highly active institutions filing the vast majority of patent applications developed by ASEAN-based inventors. The 100 institutions filing the most applications account for 81% of all 'A' and 65% of all 'W' patent applications. Most of these actors are based in Singapore or Malaysia. These applicants not only file inventions developed by ASEAN-based inventors but also form inventors abroad. The ASEAN applicants file most of their inventions at ASEAN patent authorities but for 'A' patents the US authority is an alternative option. The European authorities are playing a role for 'W' patent applications. Technology-wise, the ASEAN applicants are filing patent applications in the fields of semiconductors, computer technology, audio-visual technology, electrical machinery, apparatus, energy, measurement, biotechnology, medical technology, pharmaceuticals and digital communication.

The results presented in the sections about ASEAN applicants can be summarised as follows: ASEAN-based applicants filed around 26,000 'A' and 13,000 'W' patent applications. From these applications, two thirds of the 'A' and nearly 90% of the 'W' applications where at least co-developed by ASEAN-based inventors. Filing an application from ASEAN-based inventors and applicants based in another ASEAN country plays a minor role. Most of the applications are owned by a relatively small number of applicants. The Top-100 applicants own 81% of all 'A' and 65% of all 'W' applications developed by ASEAN-based inventors. The most active applicants are all based either in Singapore or Malaysia. The Top-10 applicant groups for 'A' and 'W' patent applications do only overlap for two companies, the Singaporean Agency for Science, Technology and Research (A*Star) and the Creative Technology Ltd. which is based in Singapore as well. This indicates that the decision to file either an 'A' or a 'W' patent application is highly depending on the institution's strategy.

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