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Regional knowledge economies and global innovation networks – the case of Southeast Asia

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Abstract

Purpose – The purpose of this paper is to discuss the prospects of a Southeast Asian knowledge economy in light of regional integration processes and the participation of Southeast Asia in global innovation networks.

Design/methodology/approach – The evidence base is a combination of quantitative data on R&D investments, patent applications and publications, with qualitative data from 40 semi-structured expert interviews conducted with innovation experts, research managers and policymakers in six ASEAN Member States.

Findings – Despite economic growth and increases in R&D inputs and outputs in individual ASEAN Member States, innovation policy at regional ASEAN level remains weak. In addition, the economic integration of the ASEAN Economic Community is progressing slowly. In this environment, evidence is presented for a certain level of regional integration when it comes to the exploitation of knowledge produced within and outside of ASEAN. While a regional market for knowledge exploitation is conceivable, this is not accompanied by the regional integration of knowledge production.

Practical implications – The main practical implication of this argument is the need for ASEAN policymakers to appreciate the disconnection between regional knowledge production and exploitation. This paper offers conceptual tools to engage in ASEAN-level policy discussions on this issue that can help facilitate the best possible regional outcome.

Originality/value – Despite several studies on the ASEAN Economic Community process, there has been no contribution so far that combines a discussion of the economic integration process with a look at the regional knowledge economy and innovation systems. This perspective does not only contribute to innovation systems literature, but also entails important policy lessons.

Keywords ASEAN, Innovation systems, Southeast Asia, Knowledge economy, Innovation policy, Global innovation networks

Paper type Research paper

1. Introduction

Southeast Asian countries regularly make the headlines as emerging economies (e.g. Indonesia and Vietnam among the "CIVETS" group of countries). Especially the larger

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Southeast Asian countries are markets and producers of global importance. They continuously attract high amounts of foreign investments. At the end of 2015, the ten-Member State Association of Southeast Asian Nations (ASEAN) has proclaimed the ASEAN Economic Community (AEC), a milestone along the region's economic integration path.

In parallel to these economic developments, some countries in the region have invested substantially in research and development (R&D). Singapore's public investments in R&D are the most visible in terms of the share of gross domestic product. Malaysia has significantly increased public and private investments in R&D as well. All countries in the region have been able to strengthen their R&D outputs as the increase of journal publications and patent applications prove.

In this article, we assess the path to the region's economic integration along with the development of its knowledge economies and innovation systems. Concretely, we address the following two questions:

Q1. To what extent does a supranational regional knowledge economy exist in ASEAN?

Q2. How is it connected to the process of economic integration and to the region's participation in global innovation and production networks?

These questions are of high political and analytical relevance for a number of reasons: Emerging economies in Asia and elsewhere are transitioning from resource and investment-based growth to a scenario where knowledge-intensive innovation becomes a main driving force of economic growth. The role supranational regional integration can play in supporting this growth is not properly assessed. In a time where economic integration models are challenged for reasons that lie outside the realm of innovation (e.g. in the EU, but also the Trans-Pacific Partnership), the question where to go in regions like Southeast Asia is of heightened urgency.

In this paper, we argue that the extent of the regional knowledge economy in Southeast Asia is currently still limited. More precisely, while there are policies and processes for a regional Southeast Asian economy of knowledge exploitation, such policies are not in place for the knowledge production aspects of knowledge economies. Knowledge production in the region's innovation systems is concentrated in local hotspots that connect to partners overseas instead of within Southeast Asia. Southeast Asian countries' integration into global innovation networks also shows an outward orientation and limited relevance of the regional ASEAN context. Southeast Asia as a region so far plays a role as an increasingly attractive set of markets for the economic exploitation of knowledge produced elsewhere. Local hotspots play an increasing role in knowledge production and channeling of knowledge produced elsewhere into the region.

In parallel to this knowledge production and exploitation runs the broader, rather slow process of economic integration in ASEAN. STI integration does not compensate for this slow path of economic integration. Regional innovation capacity is therefore likely to remain limited. In the absence of a stronger integration in STI, the growth of some national knowledge economies in the region threatens to further undercut regional integration. This could have negative long-term effects on economic performance and, potentially, regional social cohesion. Proper policies for the region as a whole should therefore be considered.

Our argument is not only relevant to STI policymakers in ASEAN and other regions. It also offers novel conceptual insights into the relevance of the supranational regional level[1] for the study of innovation systems and global innovation networks. We show that attention

to the supranational level allows uncovering spatial tensions in innovation systems between the production and exploitation of knowledge. Analysing the spatial dimension of innovation system functions such as knowledge production or market formation also adds depth to the notion of knowledge economies. National knowledge economies expand the reach of knowledge-related economic activity beyond their borders, for example, by exploiting regional markets in ASEAN. Our perspective and material also offer an innovative view onto global innovation networks (GINs). We propose a taxonomy of forms of inclusion of innovation actors into GINs. We also show that GINs do not exclusively operate in a local-to-global mode, but can include the supranational regional level in various configurations.

We build our argument by looking at macro-economic and scientometric data together with qualitative data from around 40 semi-structured expert interviews that we carried out in 2015 and 2016 (Degelsegger *et al.*, 2016). We interviewed STI policymakers, research managers, IP lawyers and innovation professionals in six of the ten ASEAN Member States: Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. The qualitative data we obtained focus on innovation framework conditions and key institutions in the innovation process with a particular emphasis on intellectual property rights regulations.

The article is structured as follows. After clarifying our conceptual framework, we give a short overview of regional integration in ASEAN with a more detailed look at economic integration and the agenda for science, technology and innovation. We then provide an assessment of the state and development of knowledge economies in the region. We use the case of intellectual property-related policies to illustrate in more detail what we believe to be disconnected integration paths between knowledge production and innovation exploitation. After a discussion of the policy implications of our findings, we conclude with a summary of the conceptual contributions we think our approach offers to the study of innovation systems and global innovation networks.

2. Conceptual framework and state of the art

At the core of this article is our concern with innovation and knowledge economies in Southeast Asia in the light of the region's model of economic integration through the AEC. We approach innovation not from a micro-level management or a meso-level diffusion-oriented perspective, but we are interested in macro-level trends and innovation policy. We understand innovation policy not in a top-down fashion as regulation, but as a set of governance arrangements involving multiple actors (Mayntz, 2006) and unfolding in different policy arenas: from subnational ones via the national level to regional (e.g. in Southeast Asia), international (e.g. bi-regional) and global arenas. The challenge of innovation policy in the various arenas is to trigger innovation performance. Innovation performance, in turn, is crucial for knowledge economies.

At the end of the 1990s, the OECD defined knowledge economies as those "directly based on the production, distribution and use of knowledge and information" (OECD, 1996, p. 7). The concept has been in wide use since then. Although it was criticised as vague and is often used as a metaphor rather than as an analytical concept (Brinkley, 2006), there have been attempts to add conceptual depth. Powell and Snellman (2004), for instance, pointed to the reliance on knowledge and the pace of knowledge production. They state that, in knowledge economies:

> [. . .] production and services [are] based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. The key component of a knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources (Powell and Snellman, 2004, p. 199).

We acknowledge the usefulness of the term to delineate broad movements of economies towards more and faster-paced knowledge-intensive production. To describe dynamics within knowledge economies in more detail, we make use of the concept of innovation systems.

The innovation systems perspective is particularly productive for our research question and from a policy point of view. Lundvall (1992, p. 12) defined innovation systems as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge". The systems of innovation concept draw our attention not only to explicit policies (such as innovation support programmes), but also to innovation framework conditions, that is, elements that influence the way innovation is carried out and that are not at the core of traditional research and innovation policy. They include, for instance, intellectual property rights (IPR) regulations, innovation-oriented tax incentives, public procurement for innovation, standards, visa regulations affecting mobility or science diplomacy issues. While framework conditions typically refer to macro-level conditions not directly related to innovation policy, we understand for example IPR regulations as "dedicated" framework conditions, as they are developed by policy but embedded in this case in the wider legal framework. The same goes for tax incentive schemes. So while IPR as such is perhaps not typically considered a framework condition, the way we have considered IPR regulations in our study approaches IPR as an embedded or dedicated framework condition. Systems of innovation encompass a structure of production and an institutional setup. The question at what level of aggregation these elements should be observed has been widely discussed.

Next to Lundvall's (and many others') concern with national-level innovation systems, other bodies of literature on innovation systems concentrate on the regional (sub-national) (Cooke *et al.*, 1997) or the sectoral level (Breschi and Malerba, 1997). Supranational innovation systems, by contrast, have not been discussed systematically. Borrás (2004) asked whether it is possible to conceptualise the European Union as a system of innovation. She acknowledges the creation of a set of formal institutions for innovation at EU level. These innovation policy institutions can be seen as a response to changes in the environment. However, at the same time as she acknowledges the growth of a formal institutional landscape, Borrás points out that informal institutions are lacking. More precisely, the set of informal institutions in place (and the spontaneous interactions of the relevant actors) does not adjust to the formal institutional landscape. Edquist and Texier (1998) also observed a disconnect between the development of formal institutions and the adaptation of the informal institutional landscape at EU level. Both Edquist and Borrás therefore suggest that it would be premature to speak of an EU level innovation system.

We argue that the question is not so much whether or not a certain supranational entity can justifiably be called an innovation system. The systems perspective is more productive when thinking about which of its aggregate-level functions are performed at what level. Broadly speaking, the concept of systems of innovation entails notions of knowledge production and knowledge exploitation through innovation. For a more detailed set of innovation system functions, Borrás (2004) proposes to distinguish a number of factors such as the production of knowledge, the diffusion of knowledge, financing innovation, the alignment of actors, the guidance of innovators, the appropriation of knowledge, the reduction of technological diversity, the reduction of risk and the control of knowledge usage. Borrás shows how different formal and informal institutions perform these functions in a system of innovation. However, the institution-focused discussion is too narrow for our purposes. While it is useful for the analysis of policy aspects in considerable detail (e.g. by focusing on risk reduction policies), it misses some of the innovation system functions

outlined by Hekkert *et al.* (2007), most notably the top-down guidance (through policy) of knowledge production and diffusion, the aspect of market formation and the question of resources mobilisation.

If we consider, for instance, market formation as a relevant function of aggregate-level innovation system performance, we can ask the question at what level markets are created (and through which institutions). Economic integration processes through entities such as ASEAN or the EU create markets at a supranational level. More precisely, they create new markets by integrating existing ones. Among other things, this changes the conditions for informal exchange, that is, user-producer relations across borders, which are relevant for innovation performance.

Asking at what spatial level innovation functions like market creation are carried out is useful for a type of analysis of innovation systems that could be described as bottom-up and that does not pre-define a level of abstraction (national, regional, etc.)[2]. Following functions instead of pre-defined regional levels of observation (which were the focus of much of innovation system literature) allows us to better observe systems-level dynamics, for example, the possible evolution of a supranational innovation system.

While the innovation systems literature is organised around horizontal spatial dimensions of national or sub-national regional innovation systems (Howells, 1999), another concept alludes to a vertical spatial integration of innovation activities: global innovation networks (GIN). According to Ernst (2009), global innovation networks (GIN) "integrate dispersed engineering, product development, and research activities across geographic borders" (Ernst, 2009, p. 1). GINs intensify technology-based global competition and foster interdependence among national economies and their innovation systems. GINs include cross-national user-producer relationships and knowledge exchange. Further, they encompass both inter- and intra-firm relationships (Liu *et al.*, 2013). The emergence of GINs signifies that the interactions leading to the transfer, creation and exploitation of tacit and codified knowledge take place not only locally. Sub-national regional innovation hubs where spatially sticky knowledge is created might be part of GINs (Chaminade and Vang, 2008). However, the concept also suggests the vertical spatial distribution of knowledge production (not only exploitation).

We bring in the concept of GINs as an interesting complement to innovation systems thinking precisely because of the verticality it implies. This verticality can be connected to innovation system functions at an aggregate level (e.g. it can be said that national innovation systems actors in a small country exploit knowledge mostly in global innovation networks of multinationals). The concept can also benefit from the bottom-up approach described above.

Just like in the case of the innovation systems literature, studies of GINs have a blind spot when it comes to the level of supranational regions such as the EU or ASEAN. It is assumed that GINs connect local level players (e.g. research intensive SMEs or university labs) with global networks (e.g. of multinational companies) and markets. The question of the relevance of intermediate layers (e.g. in view of markets or policy) is not addressed. We argue that ASEAN makes an excellent case to further explore the potential relevance of a supranational perspective on innovation systems as well as on GINs. We will provide a novel taxonomy of four ways in which companies and other innovation actors are included in GINs.

Focusing on ASEAN opens up a comparative perspective that complements the limited number of studies that exist and that focus on the EU (Borrás, 2004). Analysts have shown that regional-level integration in science and innovation is less profound in ASEAN than it is in the EU (Remoe, 2010). With Borrás (2004), we agree that it is therefore much less

justified to speak of an ASEAN system of innovation than it is to speak of an EU system of innovation. We argue, however, that this does not diminish any of the relevance of the case. Quite on the contrary, it increases its relevance, as it allows us to study dynamics in the evolution of innovation systems in a different supranational environment: AEC represents a policy push to achieve a region-wide innovation system.

As we shall see in more detail, ASEAN follows its own path of regional economic integration. Economic integration interacts with innovation system dynamics as well as with the ways innovation system actors engage in GINs. To be able to discuss these dynamics in detail, we need a more tighter conceptual grip on regional integration in ASEAN.

3. Regional integration in ASEAN

Regional integration in Southeast Asia formally started with the establishment of ASEAN in 1967. The original five Member States were later joined by Brunei (in 1984), Vietnam (1995), Myanmar (1997), Laos (1997) and Cambodia (1999). The accession of the latter four countries was only possible as a result of the end of the Cold War, adding complexity to one of ASEAN's core mandates: ensuring peace and security in the region. ASEAN succeeded in reducing security competition among its members, contributing to a more stable region (Masilamani and Peterson, 2014). Discussions are ongoing as to whether this was possible because of or despite ASEAN's type of regional integration, which is characterised by intergovernmental coordination instead of supranational consolidation of policy areas like in the case of the European Union. The so-called "ASEAN Way" is described as a:

> [. . .] working process or style that is informal and personal. Policymakers constantly utilise compromise, consensus, and consultation in the informal decision-making process. While the doctrine of "quiet diplomacy" is ambiguous, it above all prioritises a consensus-based, non-conflictual way of addressing problems (Masilamani and Peterson, 2014, p. 11).

The ASEAN Way is also reflected in the institutional setup of the Association. The ASEAN Secretariat, for instance, has no mandate to propose regional-level policies (and a very limited number of staff given the policy areas it deals with). There is no transfer of competences to the regional level, no binding regional-level legislation, no regional-level judiciary. Nevertheless, in an integration setting characterised by intergovernmental action, ASEAN's agenda has long included the issues of economic integration and regional-level cooperation in areas such as research.

3.1 Economic integration and intra-regional trade

As early as 1977, the ASEAN member countries saw in economic cooperation a way to further regional economic growth. They established the ASEAN Preferential Trading Arrangement (PTA). Under the PTA framework, tariffs on around 16,000 goods were already reduced by the early 1990s. However, they accounted for only 5 per cent of intra-regional trade. The main export and import products (including rice, etc.) remained protected by high tariff barriers.

ASEAN continued to respond to other regional economic integration efforts, not least to the European Single Market initiative, by establishing the ASEAN Free Trade Area (AFTA), the ASEAN Investment Area (AIA) and the ASEAN Framework Agreement on Services (AFAS). Major differences still exist, however, between the EU's and ASEAN's model of economic integration. ASEAN decisionmakers aim for a free trade area, not for a customs union (which would include a common external tariff) or a single market (the most

ambitious type of trade cooperation including free movement of goods, services, capital and people).

In view of the ASEAN Economic Community, the start of which was announced at the end of 2015, tariff barriers have been further reduced. Average intra-regional tariffs have fallen to 0.04 per cent among the more advanced ASEAN economies and to 1.33 per cent among CMLV countries (OECD, 2016, p. 136). The degree of economic integration has nevertheless been described as "shallow" (Dosch, 2015). Countries have made use of temporary exclusion lists and lists of sensitive goods to exclude products from free trade (rice is still on these lists, for instance). A large number of non-tariff barriers continue to exist and have actually grown in number (Ing *et al.*, 2016; Jones, 2016). These include sanitary and phytosanitary measures, technical barriers to trade, differences in standards, shipment inspections, government procurement conditions, etc. (Ing *et al.*, 2016, p. 22). Free movement of people is only envisaged for a small number of professions with a high skill level. Instead of cooperating, countries continue to compete to attract infrastructure funding (Das, 2015, p. 9). By not abolishing non-tariff and regulatory barriers in goods, services and investment, ASEAN fails to exploit the potential of the regional economy and markets.

> Instead, the rise of China and to a lesser extent India together with Japan's dominance in high technology and its aversion to technology transfer leaves ASEAN increasingly dependent on Asian investment and export markets (Jones, 2016, p. 23).

In this light, foreign direct investment and exports (and, in combination: export-oriented production facilitated through foreign direct investment) are responsible for the impressive and sustained annual GDP growth rates of 4-5 per cent (see ADB, 2015; current US$).

Indicators on trade and investment illustrate the current state of play of economic integration in ASEAN and allow for comparison with the EU. As per 2014, 24 per cent of the region's trade has been intra-regional (compared to 17 per cent in 1990)[3]. In the EU, the share is 62 per cent in 2013 in trade of goods (Eurostat, 2016a) and 56 per cent in trade in services (Eurostat, 2016b). Another interesting measure for economic integration is investment flows. In the EU, in 2012, 39 per cent of foreign direct investment (FDI) into EU-27 countries came from within the EU-27 (2010: 54 per cent) (Eurostat, 2016c). In ASEAN, in 2013, 16 per cent of inward FDI came from sources within ASEAN. In 2015, it was 18.4 per cent. As we see from these data, the level of economic integration in ASEAN can be characterised as limited, but increasing. We will see that ASEAN regional integration in the area of science and technology is even more limited.

3.2 Science and technology

Science and technology has long been on the agenda of ASEAN: After ASEAN's foundation in 1967, its Member States of that time started to discuss ways to promote and intensify cooperation in 1970. The ASEAN Committee of Science & Technology (COST) was then formally established in 1971 (in 1978 under its current name), which makes it one of the first permanent ASEAN committees. In its current composition, it meets twice a year, once at the Ministerial level and once at the level of COST chairpersons (usually Vice Ministers). COST oversees strategic plans for regional cooperation in S&T, including through several sub-committees focusing on thematic areas or on generic issues like research infrastructure. The latest of these is the ASEAN Plan of Action in Science, Technology and Innovation (APASTI), running from 2016-2025.

APASTI represents a paradigm shift in that it incorporates the area of innovation into the S&T agenda of ASEAN, a shift that was prepared from 2010 onwards when Ministers in an informal meeting agreed on the so-called "Krabi Initiative".

In parallel to the inclusion of innovation to the focus of ASEAN and COST, a second shift has taken place more recently: The area of science, technology and innovation (STI) is now part of the ASEAN Economic Community. Before 2015, it was part of the ASEAN Socio-Cultural Community.

These policy-level developments indicate that STI is visible at the regional ASEAN-level and that its scope (now including innovation) is increasing. More importantly, by now being part of the ASEAN Economic Community and not the ASEAN Socio-Cultural community, the STI agenda has been explicitly linked to the economic integration process in ASEAN. This brings us back to our research question: the interaction of an ASEAN Economic Community with a regional knowledge economy.

Investment in the knowledge economy has remained low in most countries of the ASEAN region. Gross expenditure on R&D as a share of GDP is around 0.1-0.2 per cent in countries such as Indonesia, the Philippines or Vietnam. The major exception among the ten Member States is Singapore, where around 2.1 per cent of GDP are invested in research and development. Malaysia invests around 0.8 per cent of its GDP, Thailand 0.3 per cent (OECD, 2013; Degelsegger *et al.*, 2014). The GERD/GDP shares have not risen dramatically in the last decade, but given the GDP growth rates, net investments have increased modestly.

Apart from the issue of political commitment, among the reasons for the relatively modest budgets for funding STI is also the large informal economy in some ASEAN countries. Budgets also tend to be distributed over a complex set of ministries, agencies and councils as well as private sector stakeholders[4], all representing their own specific interests, targets and priority areas. These actors sometimes work in close collaboration, adapting and aligning their activities towards the single goal of a healthy innovation landscape. In practice they often work either simply alongside if not against one another, or are catering to overlapping research areas, devising and implementing basically similar policies. There is a pattern to spread the scarce resources over too many priority areas by complex and inward-looking institutional systems, generating a substantial redundancy in bureaucracy. This situation, together with the above-mentioned intergovernmental model of regional coordination, is responsible for the lack of regional-level research investments, the still low level of GDP per capita notwithstanding.

By means of output, as our analyses within the SEA-EU-NET project[5] show (Philipp *et al.*, 2017), publication and patent output have increased significantly in ASEAN. Authors based in the region produced around 550,000 journal publications between 2004 and 2014. 24,000 journal publications with ASEAN-based authors are indexed in 2004 and 81,000 in 2014. ASEAN's share in global publication output[6] increased from 1.5 per cent in 2004 to 3.1 per cent in 2014. Among the ASEAN Member States, Malaysia and Singapore have the highest annual output. Singapore's share in regional output is 34 per cent, Malaysia's is 32 per cent and Thailand's is 21.5 per cent (all other countries are below 10 per cent).

These shares are noteworthy in the sense that Singapore has invested around US$6 bn annually in R&D, Malaysia US$2.5 bn and Thailand US$1 bn. If we only consider public sector expenditures on R&D (as these are the funds behind most publications), the Malaysian system has been even more efficient: the 32 per cent of regional publication output are achieved with US$0.5 bn of public money, while Singapore invests US$2.5 m for its 34 per cent share.

Patent application output has increased too. The European Patent Office's global PATSTAT database[7] registered around 12,000 national patent applications and 10,500 international patent applications (i.e. Version of spring 2014) with ASEAN-based inventors for the period 2003-2013. In total, 1,076 national patent applications and 441 international patent applications with ASEAN-based inventors have been filed in 2003. In the years after

2010, the annual output has been around 1,300 national filings and 1,300 international filings annually. A number that did not change over the decade. Despite modest growth in all countries, 85 per cent of the regional patent applications filed involve inventors from either Singapore or Malaysia.

The innovation impact of the region's publication and patent application output is an interesting and largely unanswered question. However, what is of interest to us is the disconnection between regional economic integration and knowledge production, with the former somewhat increasing and the latter continuing to be fragmented on a national level.

4. Disconnected integration paths

When it comes to intra-regional cooperation, publication and patent application output is less impressive than regional output in general. We already stated above that 24 per cent of trade and 18 per cent of FDI inflows in ASEAN are intra-regional. Only 5 per cent of journal publications, however, are intra-regional, that is, involve co-authors from two or more ASEAN countries. To put this number into a better perspective: 42 per cent of the publications involving ASEAN-based authors also involved at least one international co-author.

In the case of patent applications, the intra-regional co-invention share is even lower: of the around 12,000 national patent applications involving ASEAN inventors that were filed in 2003-2013, only around 300 (2.5 per cent) were regional co-inventions. In the case of international patent filings according to the Patent Cooperation Treaty, the share is 1.7 per cent.

Corresponding data for the EU put this relation of integration in trade versus integration in research into perspective. As stated above, in the EU around 60 per cent of trade (62 per cent in goods, 56 per cent in services) and 40 per cent of inward investment is intra-regional. As to the research outputs, no regional aggregated data are available. However, the intra-EU co-publications of EU Member States as a share of their overall publication output of 2000-2011 vary between around 19 per cent (for Poland) and 63 per cent (for Luxembourg). The shares of intra-EU co-publications are at 20 per cent for the UK, 22 per cent for Germany and Spain, 23 per cent for France and Italy, 29 per cent for Sweden, 32 per cent for Ireland, 33 per cent for Denmark, 37 per cent for Austria (Campbell *et al.*, 2013). In terms of international co-inventions, a 2009-study (Fraunhofer ISI, Idea Consult and SPRU, 2009) reports that exclusive intra-EU co-inventions[8] made up 4 per cent of all patent applications in the 2000-2004 time window.

The European Union can be considered a more tightly integrated entity than ASEAN according to a number of indicators (including trade and FDI inflows). In the EU, the ratio between the intra-regional trade shares and intra-regional co-publication shares is around 2-3 for most countries. In ASEAN, the intra-regional share in trade is ten times the share in co-publications. The data show that the EU's integration is not only stronger than in ASEAN according to the indicators we considered. It is also more balanced between the economy in general and the field of research and innovation. EU-level public support for research and innovation at a regional level has been part of the EU integration project since decades (the first EU Research Framework Programme started in 1984). In fact public support for research and innovation can be said to be an integral component of the Single Market programme.

ASEAN shows a certain level of economic integration (with increased intra-regional trade and FDI inflows). However, the research activities remain regionally fragmented. They pick up in some ASEAN Member States and (in cooperation with their international non-ASEAN partners) while remaining low in others.

What we learn from these numbers is that the integration on the regional ASEAN level plays little to no role in research and knowledge production of Southeast Asian countries. This comes as no surprise when one looks at the level of regional inputs to R&D. While strengthening regional cooperation in research and scientific knowledge production has been proclaimed as a goal, there is also no significant regional-level funding for research. The only regional-level funding instrument is the former ASEAN Science Fund, now called ASEAN Science, Technology and Innovation Fund (ASTIF), a US$10m endowment the interest earnings of which can be invested in regional projects. In the past, the projects that were funded were largely support to policy-making instead of actual research funding. Together with international partners, ASEAN and its Member States experiment with other forms of regional or bi-regional funding (e.g. in the form of multilateral funding schemes between ASEAN and EU Member States), but this is still tiny shares of the growing research budgets in the region. It is not comparable with what the European Union has invested at the regional level. In 2014, European Commission administered funds have been around 4 per cent of all research spending in the EU and some 20-25 per cent of all strategic or programmatic funding[9].

We can now look into the implications of this skewed integration path. In doing so, we will discuss innovation and regional integration. We will do this making use of findings from our field visits and interviews. Again using data from our interviews, we will then discuss innovation framework conditions in ASEAN in the light of the region's economic integration.

5. ASEAN knowledge economies: an ASEAN knowledge market?

It is widely accepted that modern economies achieve better performance if supported by sound knowledge production and application. In other words, economic dynamism and expansion will rest on these countries' ability to invest in knowledge, prioritise these investments and ensure returns on these investments through effective and dynamic innovation systems. The AEC has been launched to speed up the economic growth and associated capacities such as reducing trade barriers and enhancing investments. Given that export-based growth models counting on cheap factor prices (especially labour) are not a sustainable option for ASEAN growth, AEC will also rely on research and innovation-based growth. In fact, the AEC Blueprint also acknowledges this when calling for a "competitive, innovative, and dynamic ASEAN".

The development of knowledge-based growth, however, cannot be reduced to a question of relevant features of individual countries. Regional knowledge-based growth cannot be achieved through individual ASEAN Member State's investments in national knowledge economies. The globalised economic system in which the ASEAN Member States find themselves raises the issue of networks and connections, concepts that are key to the understanding of innovation in general (see e.g. Lundvall *et al.*, 1992 for the initial discussion on this).

On the one hand, domestic or national resources, networks and linkages between users and producers of knowledge make up the core of national innovation systems. On the other hand, with small or weak markets, this national context becomes an inhibiting factor to the advancement of domestic enterprises (striving to grow international), reducing the growth potential and returns on innovation.

Some ASEAN Member States are in fact well integrated in global value chains and, increasingly, global innovation networks in sectors such as pharmaceutics, automotive, food/agriculture or electronics. In global value chains, production is outsourced across borders. In global innovation networks, innovative activity itself is spread across borders,

increasingly not only within a same company, but also crossing institutional borders and making use of open innovation principles. Companies and research institutions engage in cooperation and competition, including co-production of new knowledge, knowledge transfer and various innovative activities (cf. Ernst, 2009, for instance).

Conceptually, the different forms of inclusion of companies and other innovation actors in GINs are not well discussed in literature. Based on our case, we can propose the following taxonomy. ASEAN Member States' industries are included in global innovation networks in one of the following ways:

- The first case of inclusion is by multinational enterprises' production activities in ASEAN countries increasingly including R&D. This case has been described as "local-to-global" internationalisation of private sector R&D (Bartlett and Ghoshal, 1988; Dunning and Lundan, 2009). Multinationals make use not only of cheaper, but of increasingly well-educated human resources and suitable infrastructure. They also benefit from attractive tax exemptions for FDI, especially when involving R&D investments. Examples for this type of inclusion into GINs can be found in the pharmaceutics industry (GlaxoSmithKline) or (mostly Japanese) automotive companies in Thailand, or in the electronics industry in Malaysia and Singapore. Patent (PATSTAT, April 2014) data on the most active patent applicants located in Southeast Asia also point to the electronics and hardware sector: the highest number of national patent applications, 2003-2013, is owned by Avago Pte., Ltd., which is a Singapore-based spin-off from Hewlett Packard now called Broadcom. It is also the company with the highest corporate R&D investments in Southeast Asia in 2015/2016, according to the EU's Industrial R&D Investment Scoreboard. Broadcom invested just under €1bn in 2015/2016, almost ten times the amount of the second biggest corporate R&D investor, also in Singapore: Singapore Technologies Engineering (ST Engineering), see below.
- The second case of inclusion into GINs is domestic companies that develop into multinationals. The case is much less frequent than the former, but there are examples and ST Engineering is one of these. ST Engineering is not a multinational that went to Southeast Asia to carry out R&D. Rather, it is a Singaporean company (majority-owned by the Singaporean state-owned Temasek Holding) founded in the late 1960s (as a weapons supplier) that internationalised, establishing a US headquarter in the year 2000. Other examples of this type of GIN integration are in the electronics sector (STATSChipPAC, Venture Singapore) or the medical technology sector (Biosensors International) in Singapore. Examples in other Southeast Asian countries are even less frequent. Sime Darby is one example: it is a conglomerate active in 25 countries in, among other things, palm oil production, logistics, healthcare or trade of industrial equipment. Its significant R&D investments are in agricultural research. Another prominent example of a regional conglomerate in a similar sector is the Thai Charoen Pokphand (CP) group active in the food sector. CP expanded to Hong Kong in the 1950s, to Japan in the 1960s, to mainland China at the end of the 1970s and now invests in all ASEAN countries except Brunei (in 16 countries globally). R&D at CP, which is a conglomerate covering an agriculture and food, retail and telecommunications, is limited, however. Delta Electronics, listed in Table I as a Thai company, is originally from Taiwan.
- The third case of inclusion of the Southeast Asian private sector in GINs is inclusion through SMEs. However, the number of R&D performing SMEs in Southeast Asia

Table I. EU Industrial R&D investment scoreboard 2016 (European Commission, 2016): world – 2500 companies ranked by R&D

World rank	Name	Country	Industrial sector (ICB-3D)	R&D 2015/2016 (€million)
142	BROADCOM	Singapore	Electronic & Electrical equipment	963.5
876	SINGAPORE TECHNOLOGIES ENGINEERING	Singapore	Construction & Materials	98.5
1068	HONG LEONG ASIA	Singapore	Construction & Materials	76.1
1222	CHINA YUCHAI	Singapore	Industrial Engineering	63.5
1432	DELTA ELECTRONICS (THAILAND)	Thailand	Electronic & Electrical equipment	50.7
2124	VENTURE	Singapore	Electronic & Electrical equipment	27.8
2129	SUNEDISON SEMICONDUCTOR	Singapore	Technology Hardware & Equipment	27.7
2161	BIOSENSORS	Singapore	Health Care Equipment & Services	27.0
2244	SIME DARBY	Malaysia	General Industrials	25.4
2248	TENAGA NASIONAL	Malaysia	Electricity	25.3
2260	SERI ALAM PROPERTIES	Malaysia	Construction & Materials	25.1
2440	PETROLIAM NASIONAL	Malaysia	Oil Equipment, Services & Distribution	22.3

is limited. Only a portion of them sell beyond their national borders and even in less join global innovation networks through arrangements with multinationals or other SMEs abroad, even in countries like Malaysia (OECD, 2013, p. 191). There are R&D performing SMEs in Malaysia's Multimedia Super Corridor, a high-tech special economic zone. Thailand hosts a few dozen research performing SMEs at its National Science Park as does Indonesia in the Jakarta Science Park. Singapore has a stronger base of research-intensive SMEs (e.g. in precision engineering; cf. OECD, 2013, p. 241) and of start-ups in the IT and life science area. There is no systematic data on the internationalisation of R&D performing SMEs in Southeast Asia.

- A fourth case of inclusion into GINs would be via research labs that become part of global networks through multinationals. Pharmaceutical multinationals such as GlaxoSmithKline, Bayer Healthcare or Roche have labs in Singapore. Keppel and SembCorp, both Singaporean multinationals in the offshore and marine business, carry out some of their R&D in collaboration with the National University of Singapore, for instance. ST Electronics established a cyber security laboratory with the Singapore University of Technology and Design. Rolls-Royce and Delta run joint labs with Nanyang Technological University, also in Singapore. All these labs are supported by government schemes from the National Research Foundations. In Thailand, Microsoft has set up an Innovation Centre with the Thai National Science and Technology Development Agency. In these countries and beyond, there are many contract research and joint R&D projects with multinationals, subsidiaries and local companies.

Two observations are relevant in view of these four types of inclusion into GINs. First, commercial exploitation of publicly funded research and government-mediated academia-industry collaboration (triple helix collaboration) are still limited in most countries. In Malaysia and Singapore, the private sector invests more in R&D than the public sector. In most other ASEAN countries, the situation is the other way round. Regardless of this, among the most important owners of patent applications, particularly of international PCT

patents, are universities and public research organisations. They hold patent portfolios in the hope of licensing and commercialisation – with limited success. While the statistics are not available (PROs do not publish the success rate of their technology transfer offices, etc.), the problem of unvalorised patents seems to be even more severe than in Europe (cf. European Commission, 2012; Gambardella *et al.*, 2008).

Second, in all four cases, the international innovation networks are Southeast Asian country to non-Southeast Asian country or region (outward-oriented rather than within Southeast Asia). The market aimed at is often not in the ASEAN region.

As far as multinationals are concerned, the target is often the home market(s) of the multinationals, be they national, supranational or global. The increasing innovation performance among multinationals in the region also leads to new patterns of value creation. The models of profit allocation and transfer pricing that are applied have implications for national tax authorities. Virtually or actually relocating R&D activities to countries in Southeast Asia becomes an option for multinationals not only because of tax deductions offered by the host country. Performing R&D or localising intellectual property portfolios in Southeast Asia offers indirect benefits through transfer pricing within the multinational company network. This expands the range of policy options for Southeast Asian countries to create spill over effects and include local players into global value chains. It also adds to the complexity of innovation policy-making. For the time being, countries such as Singapore or Thailand try hard to host corporate R&D centres from multinationals, regardless of where their target markets are located.

There are also domestic Southeast Asian SMEs that are able to go international. Public support for this expansion, however, is again not oriented towards the ASEAN market. Singapore, for instance, supports start-ups venturing into Silicon Valley (for the US and the global market) and the Chinese market. Other countries do not have these support structures in place and have troubles pushing their SME base to international markets.

The four cases of inclusion into GINs have shown that there is a combination of limited commercial exploitation of national public research combined with an outward orientation of knowledge exploitation. ASEAN is not a region with an integrated knowledge production and regional knowledge exploitation is also limited. We argue, however, that the latter aspect changes: ASEAN becomes more integrated as a region of knowledge exploitation.

Our research on recent policy developments shows that the outward orientation in knowledge exploitation that is pursued by some countries in the region is gradually being complemented by a better access to and exploitation of the ASEAN market with its 600 million people. The AEC-related efforts of regional economic integration contribute to this to some extent. Some other policy efforts in the area of innovation that are not related to AEC also strengthen the possibilities for regional knowledge exploitation. As we will show below, intellectual property rights-related policy efforts are a case in point. They have to be seen in the wider context of weak regional collaboration in research and innovation and the lack of a regional ASEAN-level knowledge economy. Missing regional-level policies for knowledge creation, innovation capacities or economic cohesion indicate that the formation of an ASEAN market for knowledge exploitation might not benefit ASEAN member states equally.

6. Regional innovation framework conditions: the case of IPR

The innovation performance of individual actors and entire systems does not only depend on explicit innovation policies like incentive schemes. As we indicated above, innovation performance also depends on what we refer to as framework conditions: a number of explicit and implicit policy effects that are not part of traditional technology and innovation policy.

In this chapter, we will focus on intellectual property regimes as one of these framework conditions for innovation. IPR regimes are seen as dedicated framework conditions, as they are hybrid cases between generic frameworks and innovation support policies. The case of IP most clearly illustrates the combination of outward orientation in knowledge production and inward orientation in knowledge exploitation.

Policies related to the creation and protection of intellectual property (IP) are widespread. IP is part of numerous trade-related international treaties. It is at the centre of the TRIPS agreement on Trade-Related Aspects of IPRs. IP-related regulations are also part of many bilateral free-trade agreements. These treaties, however, often exclusively focus on the aspect of IP protection and litigation possibilities in case of infringement. These are the concerns of multinationals entering new markets.

There is another side to the discourse on IP, however. The idea that the protection of IP is a necessary part of innovative activities, not only for multinationals but for universities, their spin-offs, start-ups and other SMEs. While discussions continue in literature as to the conditions under which IP systems are conducive to innovations (Moser, 2013; Boldrin and Levine, 2013), many governments have embraced the support to IP as an innovation policy measure. In this, the idea of IPR as an exchange agreement is in the foreground: temporary protection of an invention against publication of this invention (which, theoretically, can inspire new inventions).

The ASEAN Member States with major investments in R&D also have policies and regulations in place to strengthen the creation of IP resulting from local research activities. Utility models are available in some countries (they are most heavily used in Thailand and the Philippines, cf. Table II) and might actually be a very suitable instrument to facilitate innovation (Kim *et al.*, 2012). It is patents, however, that are in the spotlight of IP policies. Malaysia and Singapore have pushed this agenda for over a decade. The results of this policy push can already be seen in the nature of these countries' patent portfolio. Figure 1 shows the share of different applicant types in PCT patent applications per country. We see that Singapore and Malaysia are the countries with the largest share of public applicants (university and government/research) worldwide.

With less intensity than Malaysia and Singapore, Thailand has more recently started to focus innovation policies on IP. Indonesia, Myanmar, the Philippines and Vietnam are exploring policy options. Among these options are incentives for public sector researchers to

	Patent applications			Utility model applications		
Country	Resident	Non-res	Sum	Resident	Non-res	Sum
Brunei	20	15	35	0	4	4
Cambodia	1	74	75	0	6	6
Indonesia	663	6,787	7,450	223	116	349
Malaysia	1,269	6,081	7,350	70	97	167
Philippines	220	3,065	3,285	743	35	778
Singapore	1,143	8,579	9,722	0	62	62
Thailand	1,572	5,832	7,404	1,561	87	1,648
Vietnam	443	3,552	3,995	226	47	273
Total	5,331	33,985	39,316	2,823	454	3,287

Source: Degelsegger *et al.* (2016, p. 49), calculated from ASEAN IP portal, www.aseanip.org/ (accessed May 2016)

Table II. Patenting activity in ASEAN 2013: Applications from ASEAN residents and non-residents at ASEAN IP offices

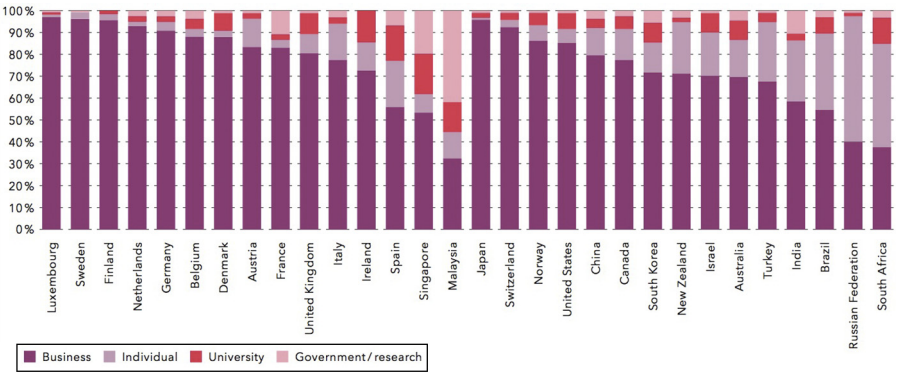

Figure 1.
Distribution of PCT applications by type of applicant

Source: WIPO (2015), Degelsegger *et al*. (2016)

patent, financial and regulatory support to technology transfer offices or the upgrade of patent offices.

As to the patent office infrastructure, Malaysia and Singapore have invested significantly throughout the last decade. This is visible in the increased numbers of filings at these offices. PCT filings at the Singapore office have almost doubled between 2003 and the 2010s (from 300 in 2003 to around 500 in 2010). In the case of Malaysia, the annual filings in 2010 (slightly above 300) were six times the number in 2006 (Philipp *et al.*, 2017). We have shown above that the numbers of patent applications with inventors and applicants in ASEAN countries are on the rise too. Quantitative studies in the SEA-EU-NET project (Philipp *et al.*, 2017) have shown that more than 80 per cent of PCT patent applications (and more than half of national patent applications) owned by entities in Southeast Asia are filed at Southeast Asian offices. At the same time, as Table II shows, the majority of filings in ASEAN IP offices is still from non-resident applicants. These numbers reflect two things: the relevance of the ASEAN market for knowledge exploitation and the pro-IP stance of the innovation policies in the region.

What we see from our interview data is that IP policies in the region focus on two aspects: To start with, they are still oriented towards the protection of foreign IP in an effort to ensure foreign direct investments. Second, they are focused on locally produced knowledge and its commercialisation. What they do not focus on is the collaborative knowledge production in international open innovation arrangements. While some regulations are in place for collaborative research with non-ASEAN partners (e.g. in joint labs between Singapore and European Union Member State partners), no such regulations exist for inner-ASEAN collaboration. This is certainly related to the fact that there are also no financial incentives for this sort of intra-ASEAN research collaboration. It is important to underline the difference between the ASEAN and the EU model in this regard. In the area of IP resulting from joint research as in other areas, the EU started with the development of regulations and incentives for the regional knowledge production. It is now exploring whether these regulations can also support international cooperation beyond the EU. ASEAN Member States again start from the perspective of international linkages outside ASEAN.

There are efforts for regional cooperation in matters of IP, however. The ASEAN Working Group on IP Cooperation promotes the accession of ASEAN Member States to

international treaties in the area of IP (like the Madrid protocol on trademark protection). The so-called ASEAN Patent Examination Cooperation (ASPEC) is an instrument for ASEAN-wide cooperation in the speeding up of patenting processes. The idea is that patent offices in ASEAN share information and accept examination reports from other offices in the region allowing applicants to obtain patent protection more easily and faster. According to interview data, ASPEC focuses not only on further simplifying procedures for multinationals seeking to enter the ASEAN market. It also allows for easier protection and exploitation of IP invented in ASEAN.

In the terminology of the innovation system functions that we introduced above, we can refer to regional cooperation in IP as one instance of regional-level market formation and of facilitation of knowledge diffusion in ASEAN. Formal institutions for this system function are built at regional level. The knowledge production function of innovation systems, however, is not regional. It is national or subnational and limited to specific ASEAN Member States. The inclusion of knowledge producing actors in global innovation networks is also limited to a small number of ASEAN Member States. As we shall argue in our concluding discussion, this combination of increasing international innovation networks with regional knowledge diffusion opportunities needs additional attention at regional policy level to be beneficial to the region as a whole.

7. Discussion and conclusions

In this paper, we have proposed a theoretical approach that sensitises readers for the spatial dimensions of knowledge economies and their innovation systems. We argued for a combination of the horizontal spatial view of traditional innovation system thinking with the vertical view embedded in the concept of global innovation networks. While other spatial levels could be explored in the same manner, we have followed evidence for the relevance of the supranational regional level in the case of ASEAN. By means of an example, we have asked what innovation system functions are carried out at this level. Improving the analysis of the spatial distribution of innovation system functions and GINs is crucial not only for understanding the case of ASEAN, but for the understanding the evolution of innovation systems and the interplay of innovation systems and economic integration.

The results presented above show that ASEAN follows a model of integration that builds on intergovernmental coordination with little decision-making power and limited resources deployed at regional level. Despite economic growth and increases in R&D spending (and outputs), innovation policy at regional level remains weak. International cooperation in knowledge production connects ASEAN countries with non-ASEAN partners, but is comparatively weak within ASEAN. The integration of ASEAN-based entities into GINs also bypasses the ASEAN level. At the same time, AEC and regional cooperation efforts in the area of IP prepare the ground for market formation and improved knowledge diffusion at the regional level. As a result of these efforts, innovation actors in ASEAN can more easily access the region's market for the exploitation of knowledge produced within and outside of the region.

Conceptually, the disconnect between dynamics of knowledge production and exploitation has to inform our understanding of regional knowledge economies. Not all supranational regional models of integration of innovation systems functions have to include both knowledge production and knowledge exploitation. Avoiding the use of the label supranational regional knowledge economy in the light of these disconnected integration paths is one option. It seems promising, however, to make conceptual use of the possibility of knowledge economies at the supranational level to better understand the role of this level in relation to local, national and global dynamics of innovation. Even in a region

with limited levels of integration, the supranational level proves important for certain innovation system functions (such as market formation and knowledge exploitation) and for the prospects of GINs.

Policy-wise, the potential problem in a scenario of disconnected integration becomes apparent when we think about the location of the actors that are able to produce and exploit research results at a regional ASEAN-level. Taking into account the current level of research outputs and the projected capacities that result from sustained investments in R&D, Malaysia, Singapore and Thailand seem to be well positioned for regional-level knowledge exploitation. These are also the countries with the strongest outward linkages in GINs. In the case of Singapore, current national-level policies aim at further upgrading the institutional landscape to exploit regional opportunities. In Singapore's IP Hub Master Plan, the country recognises the potential of combining its research capacities and a strengthened IP system with its legal and financial services industry. The idea is to be an entry point and hub not only for knowledge production, but its diffusion and the exploitation of innovations in a regional market.

This situation is unique in a global context. Other regional markets do not feature one specific hub. There is no country in the European Union, for instance, that would serve as the main entry point for knowledge exploitation in the European market. Just as knowledge production is spread over the EU, there is also no single entry point to Europe for the exploitation of non-European innovations. Among the factors in place to avoid such a situation are the more equally distributed innovation capacities, regional level instruments for inner-regional knowledge production and regionally harmonised innovation framework conditions (IP, legal security, indirect R&D incentives etc.).

Shaping one national level innovation system to act as a hub in a regional level innovation landscape is certainly beneficial for the hub. It can also help the entire region to a certain extent by attracting foreign direct investment, spurring economic activity and better serving consumer needs. However, on top of inflating the hub's patenting performance, we argue that such a situation does not exploit the full potential offered by a region like ASEAN. In the worst case, it can be detrimental to social and economic cohesion. It can also lead to protectionist policies in ASEAN Member States.

An economically better integrated ASEAN is likely to help the region to achieve and exploit productivity gains. It creates more effective linkages and cooperation in knowledge production and exploitation. The way forward is thus not a withdrawal from regional cooperation efforts, but a rethinking of regional level support to knowledge production and innovation capacities. Stronger intra-regional cooperation in knowledge production can make the process of regional-level market formation and innovation exploitation more beneficial for all parties involved. Even Singapore can benefit from this as a means to overcome limits in transforming R&D investments into productivity gains. It can further benefit from knowledge production oriented intra-ASEAN cooperation through the number of ASEAN nationals that have pursued education and research careers in Singapore. These bridges can better be exploited if the regional environment for research cooperation improves. Combining knowledge production, market formation and innovation exploitation can also decrease the reliance of ASEAN Member States' growth on non-ASEAN markets.

To strengthen regional cooperation in the knowledge production function, ASEAN does not have to leave behind its chosen model of regional integration. Instead of aspiring to establish a full-fledged ASEAN level innovation system (a result that even Europe did not achieve despite the investment of considerable resources), ASEAN policymakers might benefit from considering their national innovation systems as "loosely coupled" (Orton and Weick, 1990).

Loosely coupled systems involve distinct elements, which are however responsive. They have the potential to be both adaptable and persistent, which adds to the effectiveness in terms of system functions. The notion of loosely coupled systems has not been included in analytical work in the innovation system tradition. We suggest that the concept holds some potential when studying how national (and often specialised) innovation systems interact. The concept might also serve as an entry point for policy-level discussions that embrace the intergovernmental mode of regional integration specific to ASEAN.

Further, seeing the ASEAN region as loosely coupled illuminates the fact that key integrative mechanisms, such as extensive intra-regional trade and R&D cooperation, are still limited, thus inhibiting the overall performance of the region. This may be corrected with more active and advanced policies to support networking, linkages and exchange that provide better grounds for a region-wide and integrated knowledge economy.

From an analytical point of view, our contribution shows that a consideration of system functions at different levels of aggregation improves our understanding of innovation systems and their evolution. With the help of the case of ASEAN, we have shown how an appreciation of supranational developments improves our understanding of systems evolution. For instance, the way in which Singapore's innovation system externalises some of its functions to a regional level (while at the same time expanding local-to-global GINs into the regional level) has an impact not only on a potential regional ASEAN innovation system, but also on how innovation systems of other countries like Thailand can evolve. Our analysis also helps to contrast the evolution of national and supranational innovation system elements in different regional contexts such as the EU and ASEAN.

Ultimately, the improved understanding of different spatial levels for the evolution of innovation systems and GINs can help the development of better policy solutions. The same goes for the consideration of different levels (national, supranational, global) in relation to thinking about GINs. GINs might use local-to-global connections to exploit innovations in global markets. However, they might also relate to markets and diffusion opportunities offered at an intermediate (supranational) regional level.

For innovation policymakers in ASEAN, our analysis also suggests that there might be a need to discuss and address the evolving role of the ASEAN-level for knowledge production in light of its potential for market formation and knowledge diffusion. Appreciating the opportunities of regional cooperation for all ASEAN Member States can lead to rethinking the current approach of loose coordination without strong regional-level instruments.

Notes

1. When we speak of the "regional level" in this paper, unless otherwise stated, we refer to a supranational level (e.g. Southeast Asia or ASEAN). While Southeast Asia refers to the geographic region, ASEAN is the political grouping (much like the distinction of Europe and the EU).
2. There are limits to the functionalist perspective on innovation systems. One such limit is marked by the observation that innovation actors themselves do not perform systems-level functions. The systems level is not what they explicitly refer their actions to. Their rationales for action are motivated at a more micro-level. Nevertheless, systems-level functions emerge and can be observed at an aggregate level.
3. Intra-regional trade share published by ADB's Asia Regional Integration Centre using IMF Directions of Trade Statistics, see: https://aric.adb.org/ (accessed 28 December 2016).
4. In Malaysia, over 80 per cent of R&D investments come from private sources. In the Philippines, Singapore and Thailand, private sector share in GERD is also above 50 per cent, in all other countries it is below 50 per cent (OECD, 2013).

5. www.sea-eu.net
6. Citable and non-citable journal publications indexed in Scopus or Web of Science; sources: scimagojr.com and SEA-EU-NET.
7. Version of spring 2014.
8. That is, with no co-inventors from other countries involved; our data for ASEAN include co-inventions that have international co-inventors from both ASEAN and non-ASEAN countries.
9. GERD/GDP has been reported at 2.03 per cent or €284 billion in the EU-28 in 2014 (Eurostat, 2016d). The 2014 budget of the EU's Horizon 2020 Framework Programme for Research and Innovation was €9 billion [http://ec.europa.eu/budget/annual/index_en.cfm?year=2014 (accessed 28 December 2016)], that is, 3.2 per cent. If we add around €2 billion of national public funding that has been mobilised at the regional level (through European Research Area Networks, Joint Programming Initiatives and other schemes; see http://ec.europa.eu/research/era/pdf/era-net-statistics-2012-report_en.pdf for 2012 statistics (accessed 28 December 2016)), regional spending is at around 4 per cent in the EU.

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