Please do not cite this paper

OECD Review of Innovation in Southeast Asia

Innovation Performance and Linkages

This paper is part of a series of preliminary drafts for the *OECD Review of Innovation in Southeast Asia* provided by the OECD Secretariat. It is provided for the purpose of discussion at the SEA-EU-NET Chiang Mai Event (30 May – 1 June 2011) and for written comments by the relevant national authorities. Comments – referring, if applicable, to the respective paragraph number(s) – should be provided by e-mail as soon as possible but *no later than 30 June 2011* to the contacts given below.

This draft prepared by the OECD Secretariat will be used in Part 1 of the report of the *OECD Review of Innovation in Southeast Asia* (*Regional Overview)*, notably in the Chapters on *Overview of Innovation Capacities and their Regional Distribution* and *Intra-regional and Inter-regional Linkages*.

Contacts:

Gernot.HUTSCHENREITER@oecd.org; Michael.KEENAN@oecd.org

DRAFT

OECD Directorate for Science, Technology and Industry

INNOVATION PERFORMANCE AND LINKAGES

PRELIMINARY DRAFT

TABLE OF CONTENTS

INNOVATION PERFORMANCE AND LINKAGES *PRELIMINARY DRAFT* 2
Introduction 3
1. Economic growth and catching-up in Southeast Asia 3
1.1. Increasing living standards 3
1.1.1. Growth of GDP per capita 3
1.1.2. The contribution of labour productivity 6
2. Sources of growth 8
2.1. Physical capital accumulation 8
2.2. Human capital accumulation 10
2.3. Total factor productivity 12
3. Innovation investment and performance in Southeast Asia 14
3.1. R&D investment and its determinants 14
3.1.1. R&D performance and funding 14
3.1.2. Regulatory environment 19
3.1.3. Openness to competition 20
3.1.4. Patent rights 21
3.1.5. Financial markets 22
3.2. Innovation performance and competitiveness 26
3.2.1. Science and technology output 26
3.2.2. Industrial and macro-economic performance 31
4. Integration of the Southeast Asian region 35
4.1. Knowledge flows within Southeast Asia 35
4.1.1. Disembodied knowledge flows 36
4.2.2. Embodied knowledge flows 38
4.2. Knowledge flows between Southeast Asia and the rest of the world 43
4.2.1. Disembodied knowledge flows 43
4.2.2. Embodied knowledge flows 45
5. Some conclusions 50
REFERENCES 52

DRAFT

Introduction

1. East Asia's success is legendary. Hong Kong, Singapore, Korea, and Chinese Taipei have experienced high growth rates and rapid industrialisation since the early 1960s, converging rapidly towards the standards of living of high-income countries. Others, including major economies such as Indonesia, Malaysia, Thailand and more recently Vietnam and some of the smaller economies of the region have followed suit. Although these countries have been converging at different pace to the standard of living enjoyed in high-income countries, their trajectories have been marked by sustained growth. A variety of factors has contributed to the sustainability of growth. They include increased labour utilisation as well as labour productivity growth. The latter has been driven by the accumulation of physical and human capital, as well as innovation. The rise of China and India as economic powers has changed the environment and has a profound impact on the division of labour in this part of the world.

2. Innovation will increasingly become a determining factor for long-term economic growth of Southeast Asian countries. An increasing portion share of their growth will have to be driven by innovation, some of which based on R&D, as these countries will increasingly need to compete with other rapidly advancing economies in Asia and elsewhere in the world. Traditional sources of economic growth such as labour and physical capital accumulation alone cannot be expected to support high economic growth in the long term. At the same time, innovation capabilities vary strongly across countries in the region: some have reached a significant level while they appear still very low in some.

3. Against this background, this chapter examines the innovation performance and related linkages in the Southeast Asian region. It starts by discussing the process of economic growth and catching-up of Southeast Asian countries, examining the role played by traditional factors of economic growth and technological progress during the past decades. It then focuses on investment in science and technology and innovation performance, with a view of their determinants across Southeast Asian countries as well as selected economies in other regions of the world. The chapter finally explores science and technology linkages within the Southeast Asian region, as well as the linkages between Southeast Asian countries and selected countries in other world regions.

1. Economic growth and catching-up in Southeast Asia

4. This section focuses long-run economic growth and catching-up in selected major world regions and a sample of developing and developed countries with these regions. It first shows trends in the evolution of in the standard of living. It then underlines factors contributing to long-run growth in the regions and countries.

1.1. Increasing living standards

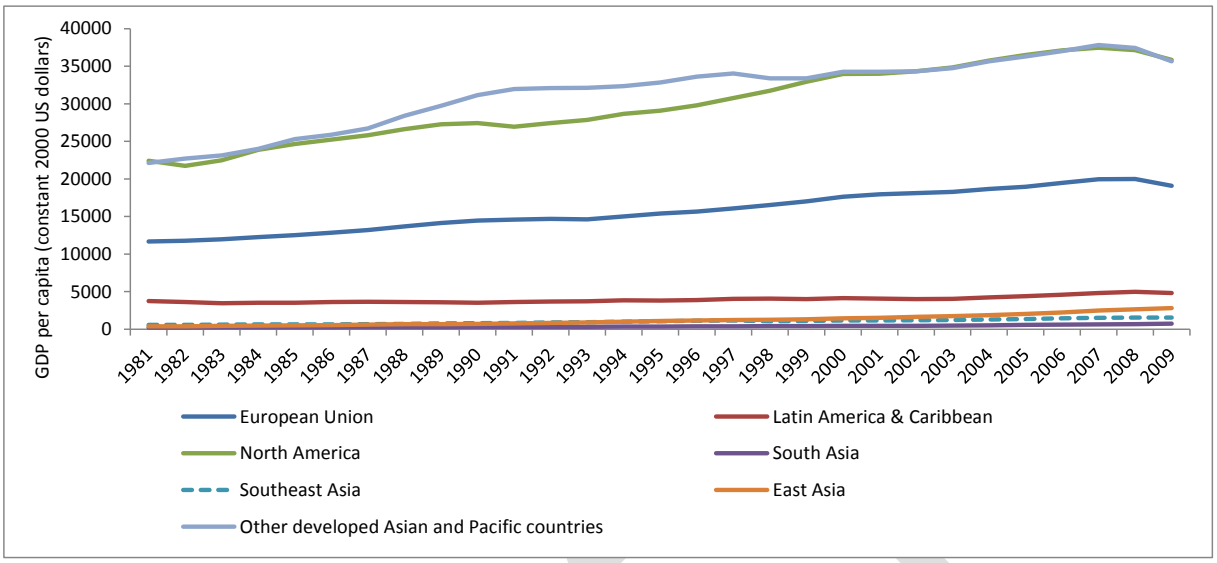
The evolution of per capita output is analysed in the selected regions and countries. It is then compared with that of GDP per person employed in order to appreciate the contribution of labour productivity to the rise of the standard of living in the regions and countries.

1.1.1. Growth of GDP per capita

5. Figure 1 shows GDP per capita (GDP divided by population) for seven major regions since 1981 (see Table 1 for the definition of regional groups). It should be noted that the current analysis does not cover the whole world economy. In particular, some of the poorest regions of the world are not included. There has been an increase in the standard of living in all the selected regions since 1981.

DRAFT

Figure 1: Evolution of GDP per capita in seven regions, 1981 – 2009



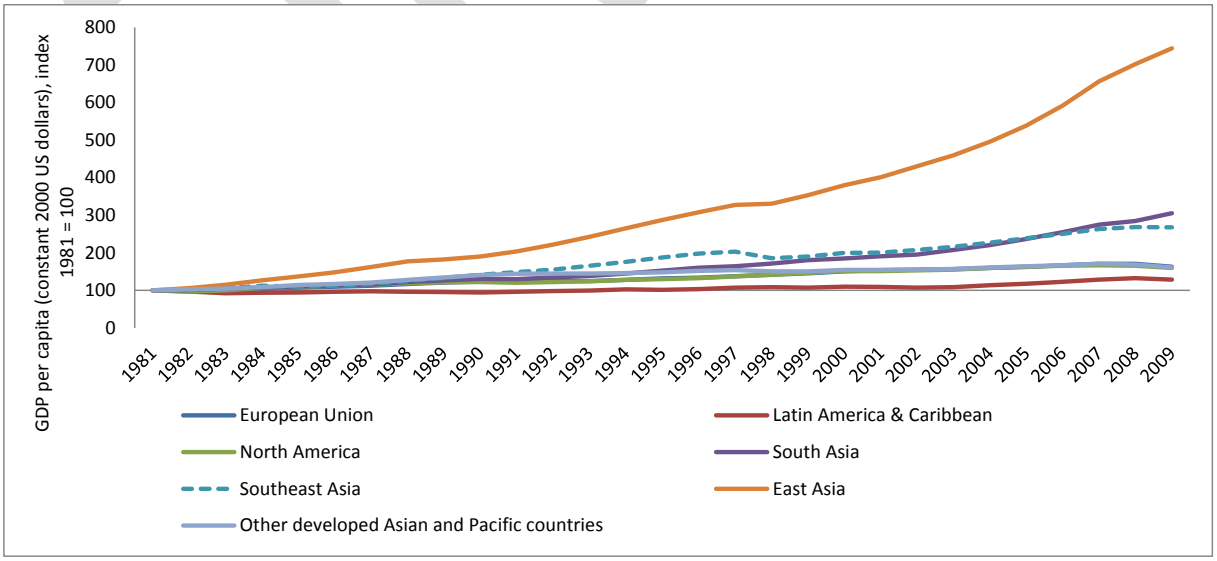
Note: No estimation is made for missing data for which data is not available. Statistics should therefore be interpreted with caution.

Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators.

6. Output per capita in Southeast Asia has grown at an annual rate of 2.6 per cent, less rapidly than that of East Asia (5.3 per cent) –including China as an engine of growth – and South Asia (2.9 per cent) but it has been more dynamic than other world regions such as Latin America (Figure 2).

7. Yet, wide regional differences in the standard of living persist across regions. In North America, the European Union, and developed Asian and Pacific countries levels of output per capita have remained higher than those of the other Asian regions and Latin America over the period under consideration. In 2009, output per capita in Southeast Asia, South Asia, and East Asia amounted to USD 1 539, USD 730, and USD 2 825, respectively.

Figure 2: Growth of GDP per capita in seven regions since 1981



Note: No estimation is made for missing data for which data is not available. Statistics should therefore be interpreted with caution.

Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators.

8. Since 1981, output per capita has risen in all the selected ASEAN and non-ASEAN countries with the exception of Brunei Darussalam (Figure 3). As predicted by economic theory, those countries that were lagging in 1981 have grown at a faster pace, thus reducing the gap between them and the more advanced countries such as the United States, Canada, Japan, Germany, France, the United Kingdom, Italy, Australia, and New Zealand. Growth of output per capita has been particularly high in Southeast Asian countries such as Viet Nam, Thailand, Malaysia, and Indonesia.

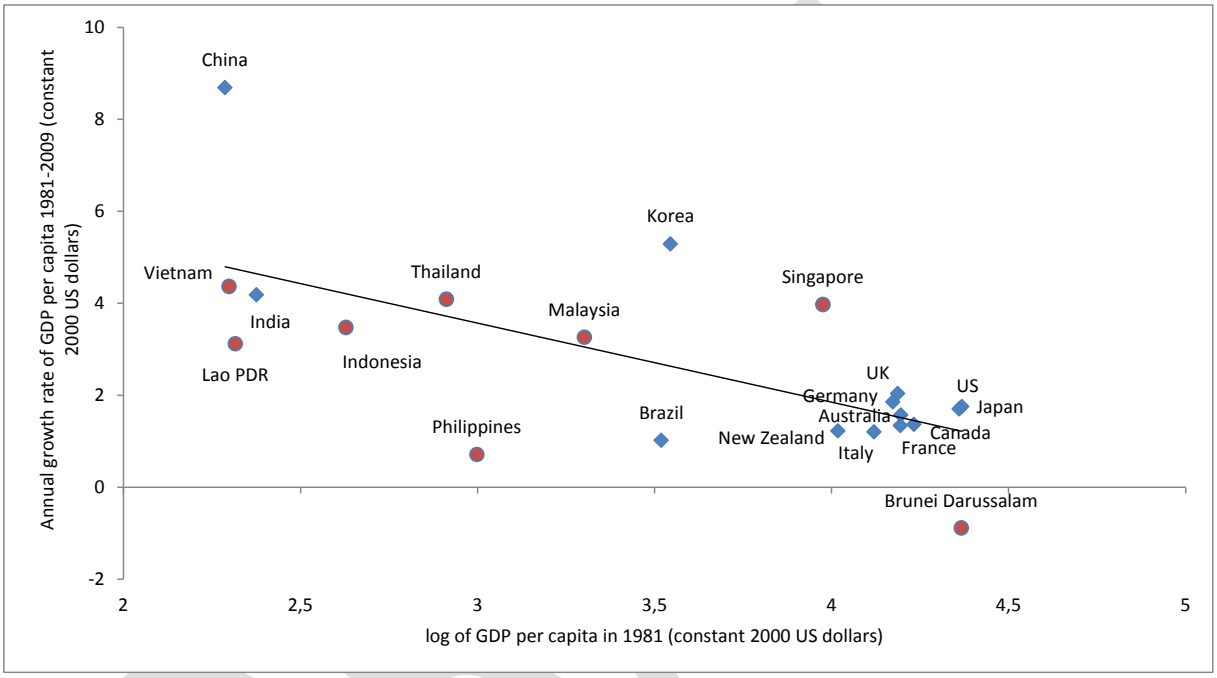
Table 1: Regional groups

European Union	Latin America & Caribbean	North America
Austria	Antigua and Barbuda	Bermuda
Belgium	Argentina	Canada
Bulgaria	Aruba	United States
Cyprus	Bahamas, The	
Czech Republic	Barbados	**Asian and Pacific developed countries**
Denmark	Belize	Australia
Estonia	Bolivia	Japan
Finland	Brazil	New Zealand
France	Cayman Islands	
Germany	Chile	**East Asia**
Greece	Colombia	China
Hungary	Costa Rica	Hong Kong SAR, China
Ireland	Cuba	Korea, Rep.
Italy	Dominica	Mongolia
Latvia	Dominican Republic	Chinese Taipei
Lithuania	Ecuador	
Luxembourg	El Salvador	**South Asia**
Malta	Grenada	Bangladesh
Netherlands	Guatemala	Bhutan
Poland	Guyana	India
Portugal	Haiti	Maldives
Romania	Honduras	Nepal
Slovak Republic	Jamaica	Sri Lanka
Slovenia	Mexico	
Spain	Netherlands Antilles	**Southeast Asia**
Sweden	Nicaragua	Brunei Darussalam
United Kingdom	Panama	Cambodia
	Paraguay	Indonesia
	Peru	Lao PDR
	Puerto Rico	Malaysia
	St. Kitts and Nevis	Myanmar
	St. Lucia	Philippines
	St. Vincent and the Grenadines	Singapore
	Suriname	Thailand
	Trinidad and Tobago	Vietnam
	Turks and Caicos Islands	
	Uruguay	
	Venezuela, RB	
	Virgin Islands (U.S.)	

Note: Chinese Tapei et Malta are not included in the aggregates for all indicators. Groups for Asian regions correspond to those used by the Asian Development Bank.

9. There is a clear negative relation between the initial level of output per capita and the growth rate achieved at the country level since 1981.[1] However, as can be expected on various grounds, this relation is not perfect. Over the period in question, Brazil and the Philippines, for example, have converged only slowly to the levels of output per capita of the initially more advanced countries. On the other hand, a Southeast Asian country, Singapore, has enjoyed sustained – and comparatively high – growth in output per capita while its initial output per capita had been high already, much closer to the levels of the OECD economies. See also the evidence on the pace of catching-up of Southeast Asian countries presented by the Asian Productivity Organization (2010).

Figure 3: Growth rate of GDP per capita since 1981 versus GDP per capita in 1981 in selected countries



Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators; OECD calculations.

10. Among Southeast Asian countries, Brunei Darussalam, Singapore, Malaysia, and Thailand had the highest output per capita in 2009 (Figure 4). In Brunei Darussalam and Singapore, levels of GDP per capita are comparable to that of developed economies in North America, the European Union, and Asia & Pacific. Conversely, the standards of living were the lowest in Viet Nam, Lao PDR, Indonesia, and the Philippines.

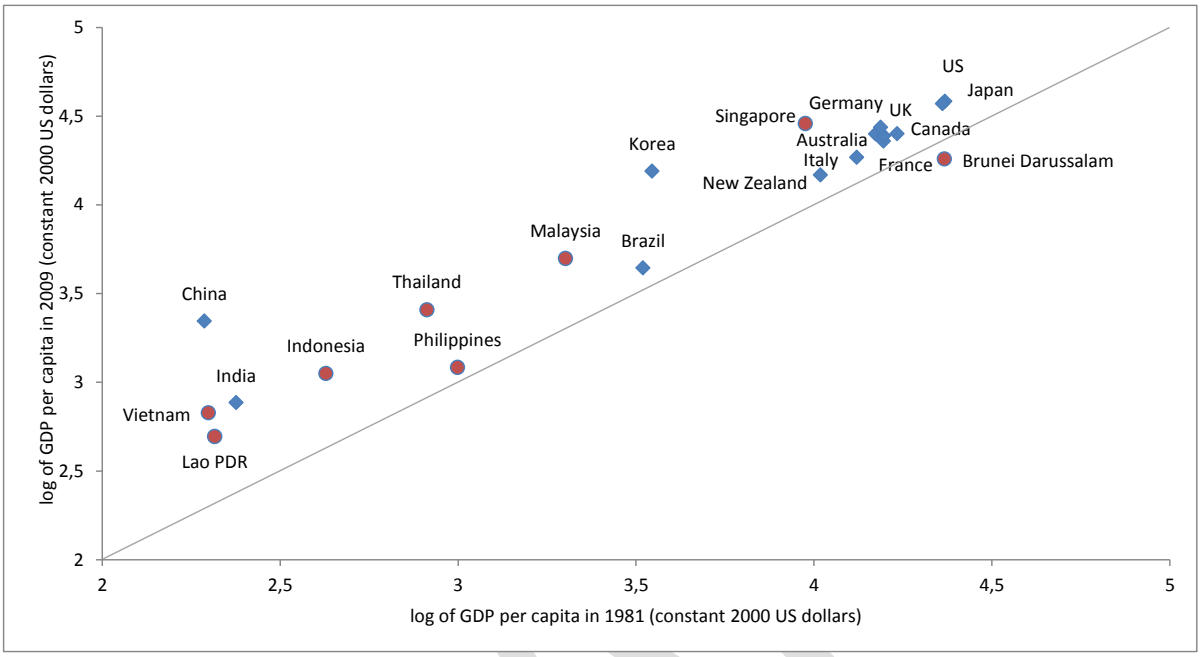
1.1.2. The contribution of labour productivity

11. From a growth accounting perspective, the changes in the standard of living standard of living can be attributed to the increases in of labour utilisation on the one hand and labour productivity on the other. More formally, GDP per capita (GDP divided by population) is a function of labour productivity (GDP divided by employment or hours worked) and labour utilisation (employment divided by population or hours worked divided by population). Figure 5 compares the annual growth of GDP per capita and GDP

[1] This negative relation between initial level of output per capita and its growth rate is not specific to the countries under consideration. It has been observed in different circumstance and is consistent, for instance, with the neoclassical growth model. See, e.g. Barro (1997).

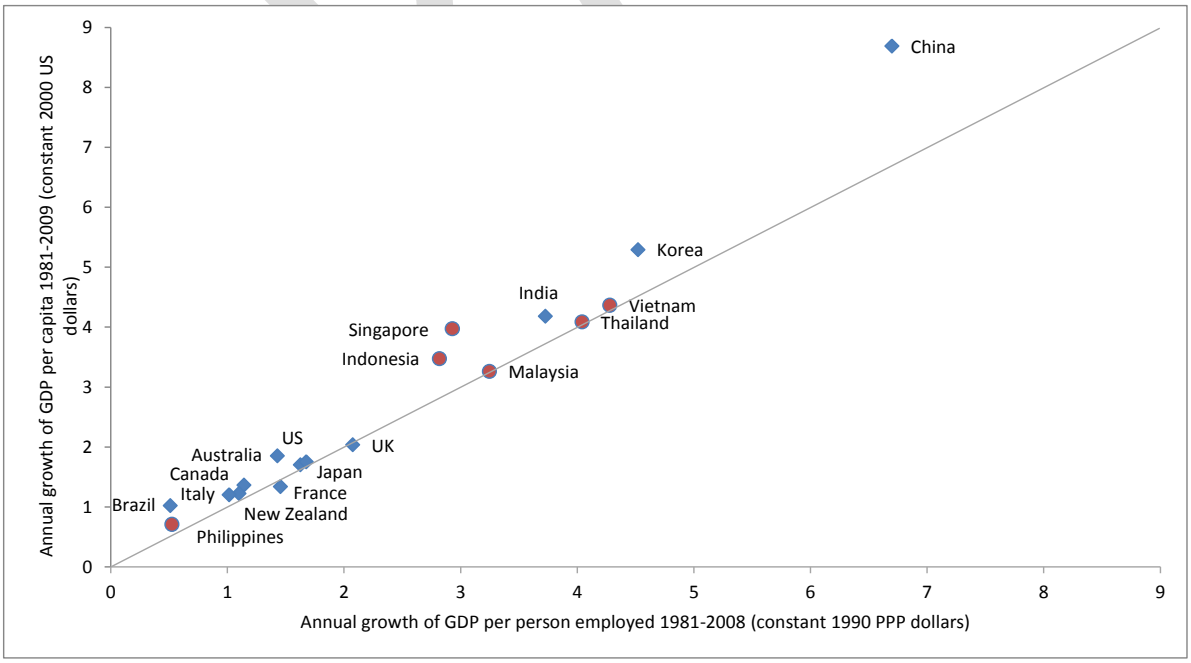
per person employed since 1981 for a sample of countries in major world regions. In the majority of countries labour productivity, as measured by GDP per person employed, has grown at the same pace as GDP per capita over that period.

Figure 4: Level of GDP per capital in 2009 versus GDP per capita in 1981 in selected countries



Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators.

Figure 5: Growth of GDP per capita versus growth of GDP per person employed in selected countries since 1981



Sources: World Bank national accounts data, and OECD national accounts data files; International Labour Organization, Key Indicators of the Labour Market database; World Bank World Development Indicators.

12. In some – mainly Asian – countries growth of per capita output has significantly outpaced labour productivity growth during that period. This is the case for Indonesia, Singapore, India, and Korea. This suggests that increasing labour utilisation has also significantly contributed to the rise in output per capita in these countries.

13. The Asian Productivity Organization provides data on the contribution of labour utilisation (as measured by the employment rate) and labour productivity (as measured by GDP per person employed) to GPD capita for a number of Southeast Asian countries since 1995 (Asian Productivity Organization 2010). From 1995 to 2000, per capita output growth was mainly driven by labour productivity in all these countries except in Indonesia, Brunei Darussalam, Malaysia, and Singapore. In these countries, improved labour utilisation also contributed to the growth in output per capita. Yet, from 2000 to 2007, increasing labour productivity was the main source of growth in output per capita in the majority of Southeast Asian countries, except for Brunei Darussalam and Cambodia.

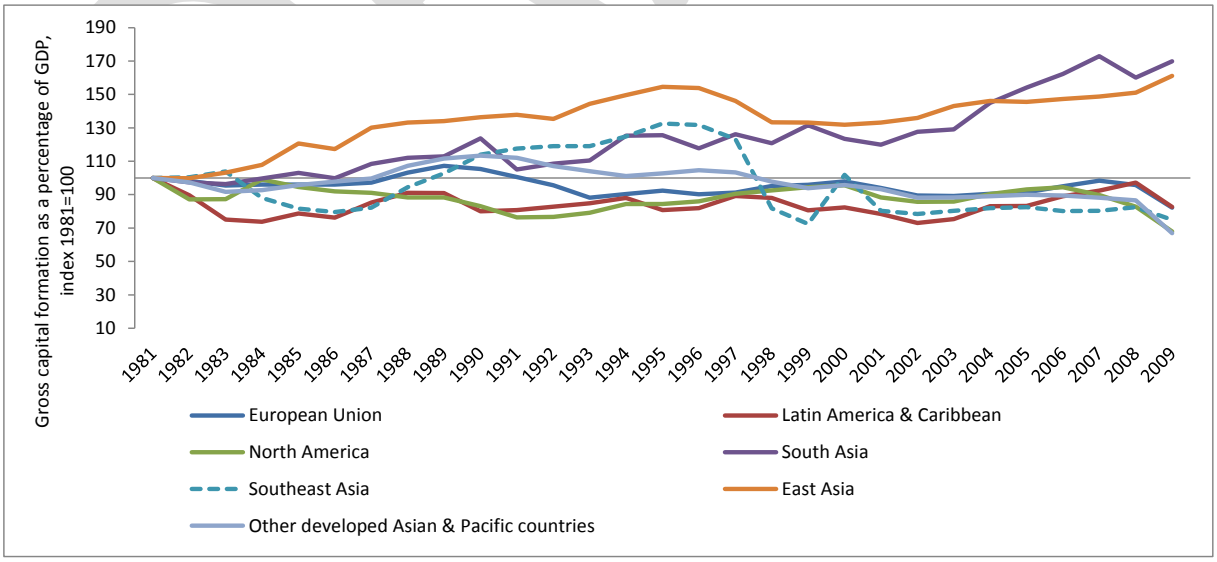
2. Sources of growth

14. Economists have suggested by different reasons to explain the rapid catching-up process of Asian countries, particularly the East Asian newly industrialising countries, after the end of World War II (Page, 1994; Rodrik, 1995; Collins and Bosworth, 1996; Stiglitz, 1996; Nelson and Park, 1999). More recent studies have extended to Southeast Asian countries, India, and China (Bosworth and Collins, 2007; Park, 2010). Major source relate to the accumulation of physical and human capital (Krugman, 1994; Young, 1995; Senhadji, 2000; Lau and Park, 2003; Park, 2010) but the role of technological change needs to be taken into account.

2.1. Physical capital accumulation

15. Figure 6 shows the growth of gross capital formation as a percentage of GDP for seven major regions since 1981. The share of gross capital formation in GDP has decreased in all regions but East and South Asia.

Figure 6: Growth of gross capital formation in seven regions since 1981

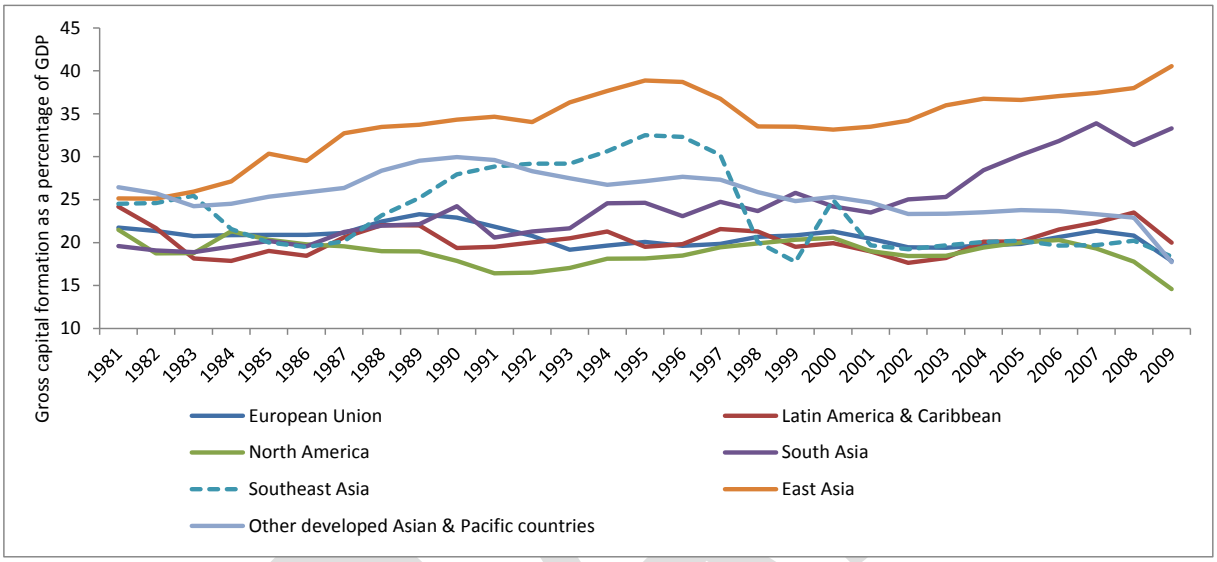


Note: No estimation is made for missing data. Statistics should therefore be interpreted with caution.

Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators; OECD calculations.

16. As shown byFigure 7, the share of gross capital formation in GDP has remained much higher in East Asia than in North America and the European Union during most of the period. This share has also sharply increased in South Asia since the beginning of the 2000s. In 2009, it amounted to about 33.3 per cent in 2009, against approximately 40.5 per cent in East Asia. Southeast Asia shows a trend in gross capital formation as a percentage of GDP that differs from all the regions under consideration. While this share increased rapidly from the mid-1980s to the mid-1990s it has sharply decreased in the wake of the Asian crisis and has stabilised at a significantly lower level. In 2009, it amounted to about 18.4 per cent.

Figure 7: Differences in gross capital formation in seven regions since 1981

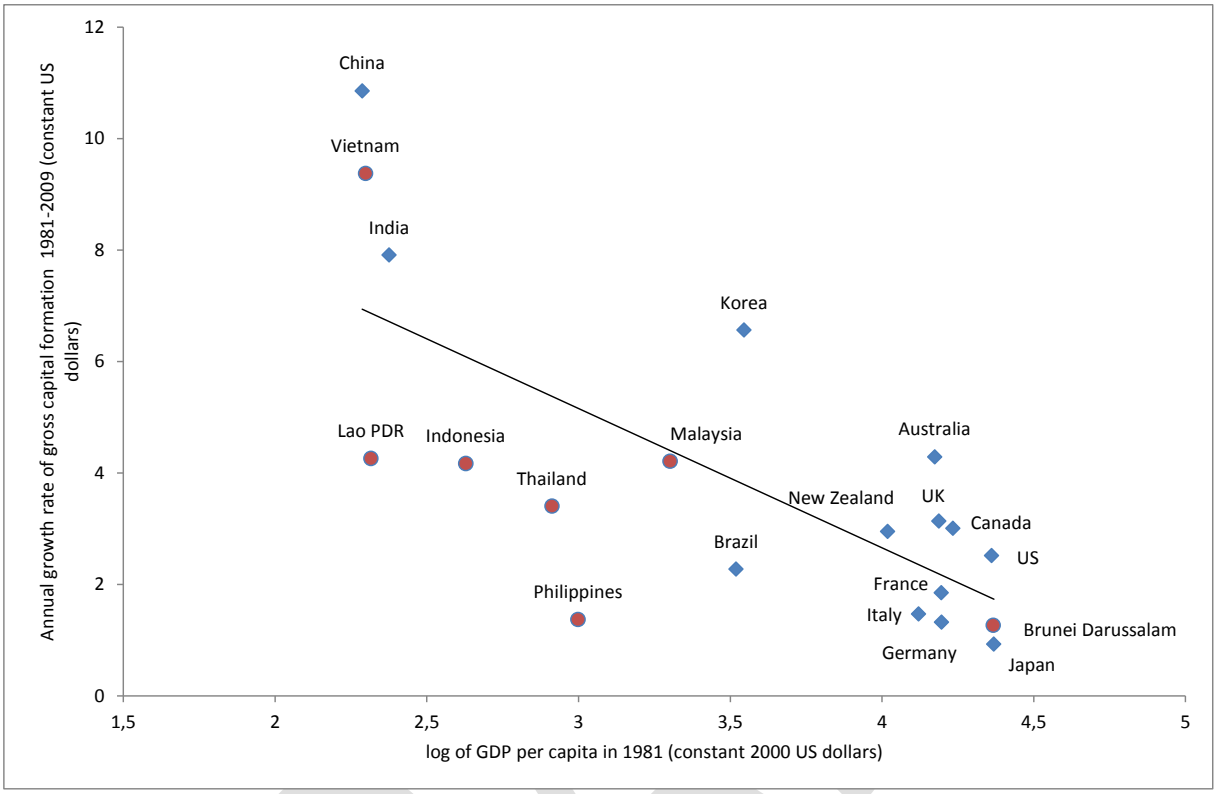


Note: No estimation is made for missing data. Statistics should therefore be interpreted with caution.

Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators; OECD calculations.

17. The growth in gross capital formation since 1981 has been high especially in countries with a low initial level of output per capita (Figure 8). This is particularly clear for China, Viet Nam, India, and Korea which have enjoyed average annual growth rates in gross capital formation higher than 7 per cent over the period. Among the selected countries, there is a negative relation between the rate of gross capital formation since 1981 and the initial level of output per capita.

Figure 8: Growth rate of gross capital formation since 1981 versus GDP per capita in 1981 in selected countries



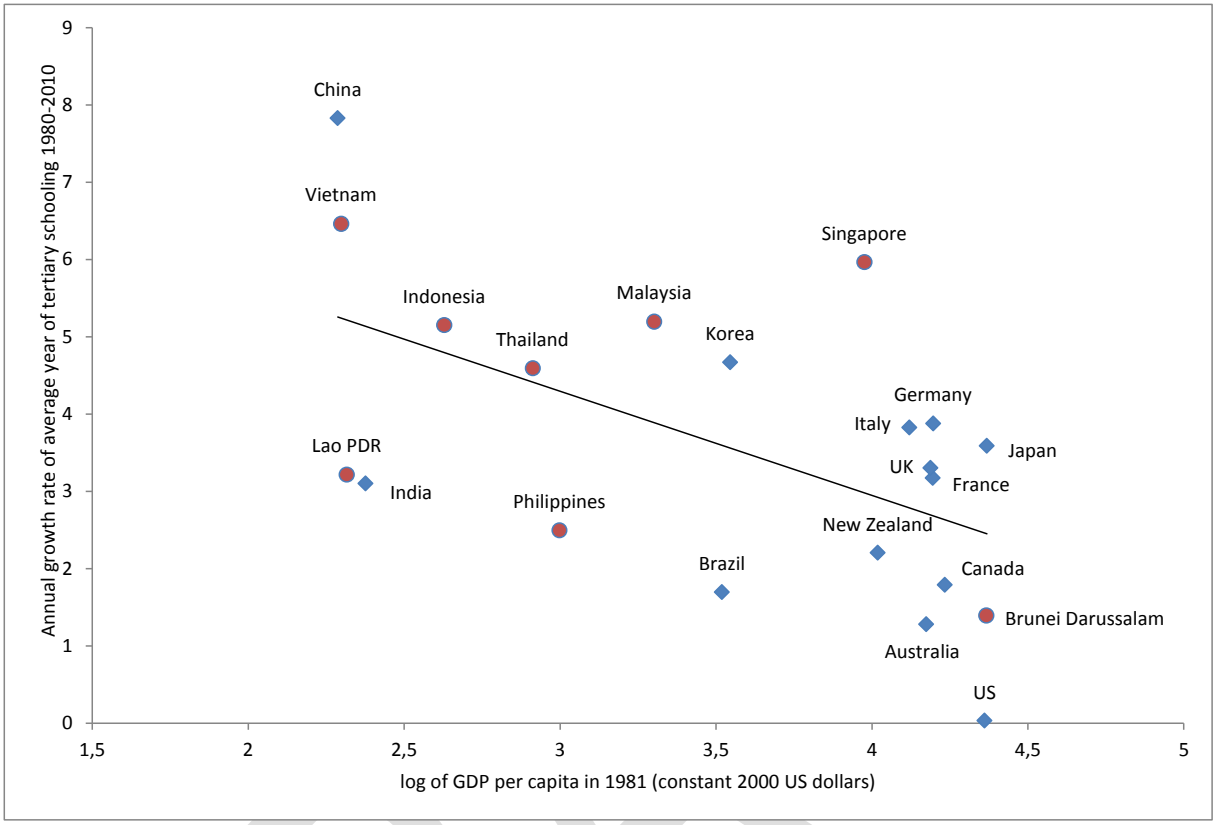
Sources: World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators.

18. Again the relation is not perfect as the Philippines and, for example, Brazil have not succeeded to achieve high annual growth rates of gross capital formation despite their relative low initial level of output per capita. Their growth rates have nevertheless been higher than those of some high-income countries, including Japan and Germany.

2.2. Human capital accumulation

Figure 9 shows the growth of the average years of tertiary schooling in the selected countries since 1980 against their level of output per capita in 1981. The average years of tertiary schooling is derived from the updated Barro and Lee dataset on educational attainment at the world level (Barro and Lee, 2010). Tertiary schooling rather than total schooling is chosen as it is widely acknowledged as a key contribution for technological progress (Vandenbussche, Aghion and Meghir, 2006). It may be noted here, however, that a broad range of skills at different levels is required to feed innovation, in catching-up economies, but also in more advanced countries.

Figure 9: Growth rate of average years of tertiary schooling since 1980 versus GDP per capita in 1981 in selected countries



Sources: Barro and Lee (2010); World Bank national accounts data, and OECD national accounts data files; World Bank World Development Indicators.

19. There is a negative relation between the growth of average years of tertiary schooling and the initial level of per capita output. In other words, countries with a low initial level of per capita output in 1980 have been marked a high rise in their stock of tertiary education. Among Asian countries, China, Viet Nam, Singapore, Indonesia, Malaysia, Thailand, and Korea show annual growth rate of average years of tertiary schooling higher than 4.5 per cent over the period. However, some Asian countries, including Lao PDR, Indonesia, and Thailand, did not expand the stock of tertiary education at this pace. Nevertheless the annual growth rate of the stock of tertiary education in these countries has remained higher than that of countries with a high initial level of per capita output.

20. This section depicted some patterns of growth in the long run in major world regions, including Southeast Asia, underlining some factors that have contributed to growth in output per capita in these regions. From the preceding developments, it can be concluded that countries that had a low output per capita at the beginning of the 1980s have generally been characterised by higher growth in their standards of living than countries which had already a high initial output per capita. This is particularly clear for Southeast Asian countries such as Thailand, Malaysia, and Viet Nam. Labour productivity growth has contributed significantly to the rise of output per capita in these countries. The latter are likely to put other more developed countries in Asia – including Hong Kong, Singapore, Korea or Chinese Taipei – under increasing pressure to increase their performance and competitiveness in the future.

21. However, some developing countries are converging at a slower pace than others to the standards of living of advanced economies in North America, Asia, and the European Union. This is particularly

clear for Southeast Asian countries such as the Philippines, Lao PDR, and Indonesia. This shows that the catching-up process is not "inevitable" but requires that developing countries undertake measures to facilitate the convergence towards the levels of standard of living of high-income economies. These measures should not only favour the accumulation of traditional inputs to growth such as physical capital and labour but also support the formation of innovation capabilities to make good use and contribute to technological progress, but also to succeed in non-technological innovation.

22. The majority of countries with a low per capita output in the beginning of the 1980s have expanded their stock of physical capital more rapidly than countries that had already a high initial output per capita. In Southeast Asia, only the Philippines has not accumulated physical capital at the same pace as other countries with an initial low per capita output. Conversely, Singapore has kept on accumulating physical capital at a high pace despite its relative high initial output per capita. Moreover, most countries with a low level of output per capita in 1981 have increased their stock of tertiary education faster than those with high standards of living at the beginning of the period. Among the Southeast Asian countries for which data is available, this is particularly evident for Viet Nam, Malaysia, and Indonesia. Among the Southeast Asian countries with a low per capita output at the beginning of the period, the Philippines has expanded its stock of tertiary education at a slower pace than other. In contrast, Singapore has expanded its stock of tertiary education rapidly despite its relative high initial level of output per capita.

2.3. Total factor productivity

23. While acknowledging the importance of physical and human capital accumulation, some Asian countries have succeeded in mobilising another powerful source of growth which contributed to their rapid catch-up.[2] Although the coverage is incomplete, the available empirical evidence – such as the data compiled by the Asian Productivity Organization (2010) – confirms the critical role played by total factor productivity[3] growth, measuring the efficiency of the use of factors of production are put to use, a proxy of technological progress, in a number of Asian countries over the last four decades.

DRAFT

[2] On the role of technological change, and more generally innovation, in the catching-up process see, e.g., World Bank, 1993; Sarel, 1997; Nelson and Park, 1999; Iwata, Khan and Murao, 2002 and Park, 2010.

[3] From a growth accounting perspective, the growth of output can be decomposed in changes in the amount of capital, changes in the amount of labour, and changes in total factor productivity. Total factor productivity is therefore the part of growth than cannot be explained by the accumulation of traditional inputs: physical capital and labour. It is often used to proxy technological progress. It should be noted, however, that the sources of TFP growth are varied.

Table 2: Output growth and contribution of labour, capital and TFP in selected countries, 1970-2007

Country		Output	Labour	Capital		TFP
				IT	non-IT	
Indonesia	1970-1985	6,91	1,19	0,12	4,36	1,24
	1985-1995	7,53	1,26	0,29	3,99	1,99
	1995-2000	0,75	0,17	0,34	3,42	-3,18
	2000-2007	4,97	1,00	0,29	2,15	1,54
	1970-2007	5,88	1,04	0,22	3,72	0,90
Japan	1970-1985	4,31	0,28	0,26	3,22	0,55
	1985-1995	3,13	-0,05	0,36	1,88	0,94
	1995-2000	0,99	-0,63	0,29	0,93	0,40
	2000-2007	1,56	-0,28	0,32	0,30	1,21
	1970-2007	3,03	-0,04	0,30	2,00	0,76
Korea	1970-1985	7,15	1,65	0,26	5,92	-0,68
	1985-1995	8,35	1,33	0,42	4,17	2,43
	1995-2000	4,32	0,27	0,47	2,94	0,64
	2000-2007	4,52	0,15	0,42	1,88	2,08
	1970-2007	6,60	1,09	0,36	4,28	0,86
Philippines	1970-1985	3,56	2,10	0,25	3,72	-2,51
	1985-1995	3,43	0,96	0,17	1,49	0,81
	1995-2000	3,99	0,61	0,55	2,40	0,42
	2000-2007	4,98	0,93	0,80	1,37	1,88
	1970-2007	3,85	1,37	0,38	2,49	0,39
Thailand	1970-1985	6,14	1,38	0,08	2,65	2,03
	1985-1995	9,06	1,19	0,26	4,54	3,07
	1995-2000	0,47	0,16	0,23	3,19	-3,11
	2000-2007	5,00	0,95	0,30	1,10	2,65
	1970-2007	5,95	1,08	0,19	2,94	1,74
China	1970-1985	7,41	1,27	0,04	3,96	2,14
	1985-1995	9,57	0,91	0,10	4,37	4,18
	1995-2000	8,28	0,62	0,22	4,78	2,66
	2000-2007	9,71	0,50	0,85	5,40	2,96
	1970-2007	8,55	0,94	0,23	4,45	2,92
United States	1970-1985	3,11	1,05	0,31	0,99	0,76
	1985-1995	2,85	0,93	0,50	0,62	0,80
	1995-2000	4,18	1,23	0,80	0,74	1,41
	2000-2007	2,38	0,19	0,53	0,74	0,92
	1970-2007	3,05	0,88	0,47	0,81	0,89

Note: The unit is percentage.

Source: Asian Productivity Organization (2010).

24. From 1970 to 2007, total factor productivity contributed between 10 and 40 per cent to output growth in Indonesia, Japan, Korea, Thailand, and China. Its contribution was even higher in Indonesia, Japan, Korea, Thailand, and Indonesia over the past decade (Table 2). Moreover, recent projections on total factor productivity growth for a number of Southeast Asian countries for the forthcoming decades indicate that it is likely to play a crucial role for growth in these countries (Park, 2010). Technological change and innovation more generally are likely to become more prominent in the future in Southeast

Asian countries as investments in physical capital face diminishing returns and be insufficient to strengthen growth in the long run. As countries close the gap vis-à-vis the leading countries they can be expected to shift the balance between adoption and generation of new technology.

3. Innovation investment and performance in Southeast Asia

25. This section emphasises the role of R&D and innovation in Southeast Asia and the other selected world regions and countries. It first highlights trends in R&D investment and identifies some of its main determinants. It then discusses the outcomes of R&D and innovation investment in these regions and countries.

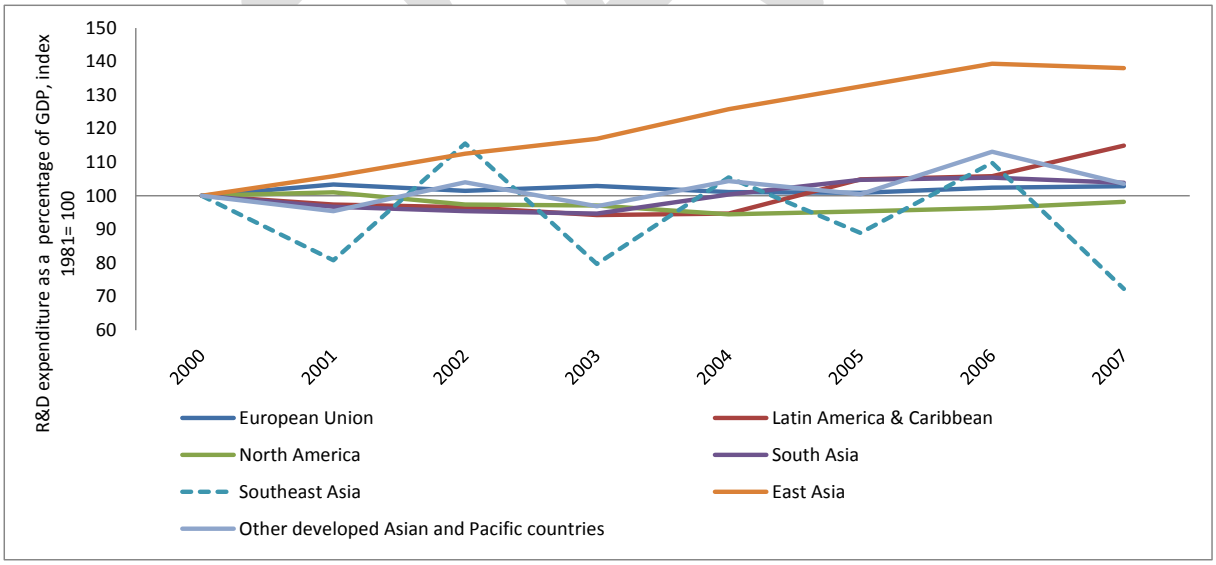
3.1. R&D investment and its determinants

26. After presenting patterns in R&D performance and funding, the role of various framework conditions – the institutional environment, human capital capacity, financial markets, and business environment –in determining R&D investment is examined.

3.1.1. R&D performance and funding

Figure 10 shows the growth of R&D intensity (gross domestic expenditures on research and development divided by GDP) for the selected seven world regions since 2000. Compared to the other regions, particularly the most developed ones, R&D intensity has increased substantially in East, South, and Southeast Asia during the period.

Figure 10: Growth of R&D intensity in seven regions since 2000



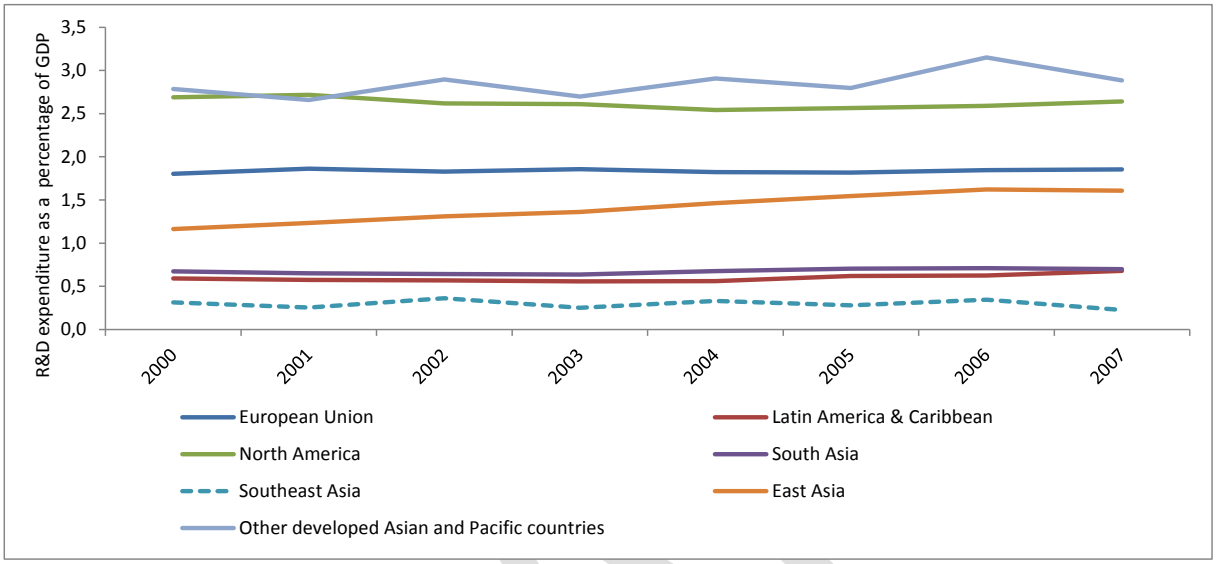
Note: No estimation is made for missing data. Statistics should therefore be interpreted with caution.

Sources: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; World Bank World Development Indicators; OECD.

27. Despite these cross-regional differences in the growth R&D intensity, there nevertheless some wide disparities in the levels of R&D intensity in these regions (Figure 11). With R&D intensities above 2.5 per cent during the period, North America and the developed countries in Asia & Pacific (owing to the

Japanese R&D effort) have outperformed the other selected regions, namely Southeast Asia, South Asia, East Asia, Latin America & Caribbean, and a lesser extent the European Union. Since 2000, the share of gross domestic expenditures on R&D in GDP in the Southeast Asia has remained below 0.5 per cent, below the one prevailing in East and South Asia. In 2007, it amounted to about 0.23 per cent against 0.70 and 1.61 per cent, respectively, in East Asia and South Asia.

Figure 11: Differences in the levels of R&D intensity in seven regions since 1981



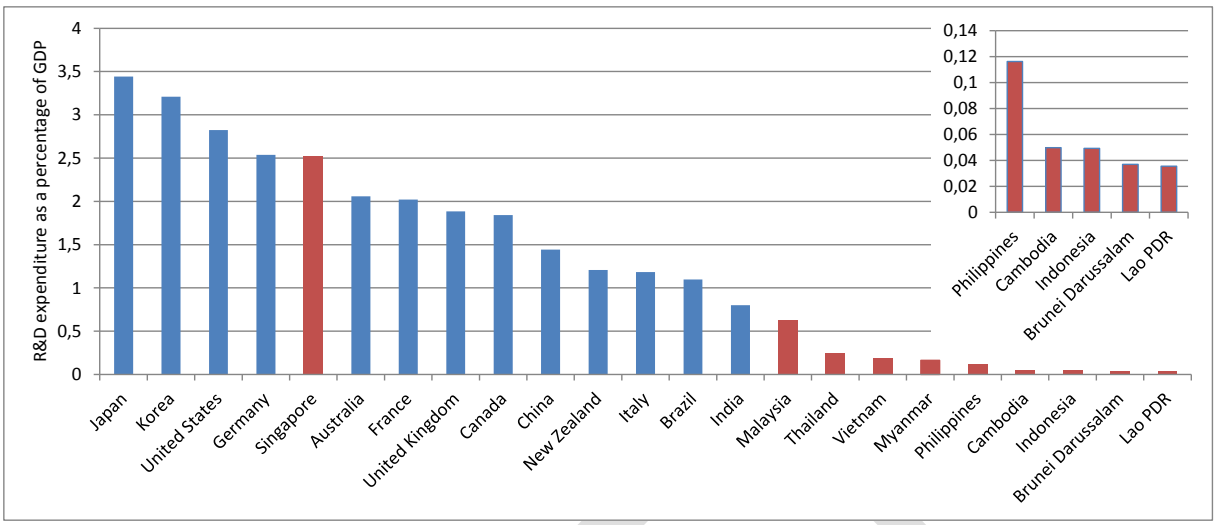
Note: No estimation is made for missing data. Statistics should therefore be interpreted with caution.

Sources: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; World Bank World Development Indicators; OECD.

28. Looking at R&D intensity across the selected countries for which data is available reveals that all the Southeast Asian countries but Singapore are lagging behind the others (Figure 12). In these countries, R&D intensity is lower than in the United States and in major EU countries such as Germany, France, the United Kingdom, and Italy.

29. The majority of the Southeast Asian countries also invest less in R&D relative to their GDP than some emerging economies in East Asia, notably China, and in South Asia, notably India. Among the sample of selected countries, two Asian countries – namely Japan and Korea – outperform the others in terms of R&D intensity. In 2007, their R&D intensity amounted to 3.44 and 3.21 per cent respectively.

Figure 12: GERD as a percentage of GDP in selected countries, latest year available



Notes: 2008: France, Italy, United Kingdom, Canada, United States; 2007: Singapore, New Zealand, Korea, Japan, China; Germany, Brazil, India; 2006: Australia, Malaysia, Thailand, 2005: Indonesia, Philippines; 2004: Brunei Darussalam, 2002: Cambodia, Viet Nam, Lao PDR, Myanmar.

Sources: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD; World Bank World Development Indicators; OECD.

30. Looking at the distribution of total R&D expenditure by sector of performance reveals different patterns of organisation of R&D activity across Southeast Asian countries (Table 3). R&D is mainly performed in the government sector in Brunei Darussalam, Indonesia, Lao PDR, and Malaysia. In contrast, the business sector performs a large share of R&D in countries with the highest R&D intensities: Malaysia, Singapore, and Thailand. The higher education sector performs a significant share of R&D in Thailand and to a lesser extent in the Philippines, Singapore, and Viet Nam.

31. Table 4 shows information on total R&D expenditure by source of funds in the selected countries for which data is available. Among the Southeast Asian countries, R&D is mainly financed by the government sector in Brunei Darussalam, Indonesia, and Viet Nam. The business sector provides substantial funds to R&D in Thailand, Singapore, the Philippines, and Malaysia. In all these countries but Malaysia, the government sector remains also active in the funding of R&D. In Thailand, the higher education funds more than 10 per cent of total R&D expenditure while the private non-profit sector is a substantial source of funds in Viet Nam.

DRAFT

Table 3: GERD by sector of performance (as percentage of total) in selected countries, latest year available

	Government	Business entreprise	Higher education
Australia	13,7	58,3	25,1
Brazil	21,3	40,2	38,4
Brunei Darussalam	91,6	2,3	8,4
Cambodia	25,3	12,1	11,8
Canada	10,4	54,1	34,9
China	19,2	72,3	8,5
France	16,1	63,0	19,7
Germany	13,9	70,0	16,1
India	66,0	29,6	4,4
Indonesia	96,2	3,7	..
Italy	13,2	50,9	32,6
Japan	7,8	77,9	12,6
Korea	11,7	76,2	10,7
Lao PDR	50,9	36,9	12,2
Malaysia	5,2	84,9	9,9
Myanmar	..	..	..
New Zealand	27,3	42,7	30,0
Philippines	18,6	58,6	21,3
Singapore	12,2	66,8	21,0
Thailand	17,2	40,9	38,3
United Kingdom	8,3	64,2	25,2
United States	10,6	72,6	12,9
Vietnam	66,4	14,5	17,9

Notes: 2009: Canada; 2008: France, Italy, United Kingdom, United States; 2007: Singapore, New Zealand, Korea, Japan, China; Germany, Brazil, India; 2006: Australia, Malaysia, Thailand, 2005: Indonesia, Philippines; 2004: Brunei Darussalam, 2002: Cambodia, Viet Nam, Lao PDR.

Sources: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

32. An abundant literature has explored the different determinants of R&D investment and, more broadly, innovation performance

33. Many studies have drawn on the national innovation systems approach. The latter approach stresses that the respective roles of actors involved in the innovation process and interactions among them are influenced by a variety of factors that exhibit some degree of country specificity: macro-economic context and regulatory context, labour market conditions, product market conditions, communication infrastructures, education and training system, factor market conditions, etc. (Freeman, 1988; Lundvall, 1992; Nelson, 1993; OECD, 1999 and 2002). From a policy perspective, this approach has recently been extended by the concept of innovation policy-mix, which puts a greater emphasis on the mix between traditional technological supply and demand-side policies and broader framework policies that could be set up to ensure more coherence and better performance of national innovation systems (European Commission, 2003; OECD, 2010a and 2010b).

Table 4: GERD by source of funds (as percentage of total) in selected countries, latest year available

	Government	Business entreprise	Higher education	Private non-profit
Australia	37,3	58,3	0,1	1,8
Brazil	52,9	44,7	2,4	..
Brunei Darussalam	91,0	1,6	7,4	..
Cambodia	17,9	..	..	43,0
Canada	33,1	47,5	6,8	3,3
China	24,6	70,4	..	..
France	39,4	50,5	1,3	0,8
Germany	27,7	67,9	..	0,4
India	66,0	29,6	4,4	..
Indonesia	84,5	14,7	0,2	..
Italy	44,3	42,0	1,3	2,9
Japan	15,6	77,7	5,6	0,7
Korea	24,8	73,7	1,0	0,3
Lao PDR	8,0	36,0	2,0	..
Malaysia	5,0	84,7	9,7	..
Myanmar	..	..	..	..
New Zealand	42,7	40,1	8,7	3,7
Philippines	25,6	62,6	6,0	0,7
Singapore	34,9	59,8	0,9	..
Thailand	31,5	48,7	14,9	0,7
United Kingdom	29,5	47,2	1,2	4,5
United States	27,0	67,3	2,7	3,0
Vietnam	74,1	18,1	0,7	..

Notes: 2009: Canada; 2008: France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam, Lao PDR; 2001: Indonesia.

Sources: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

34. Other, thematically more narrowly focused quantitative studies have examined the impact of different public policies and institutions (e.g. fiscal incentives for private R&D, the role of public research organisations, the intellectual property rights regime, the availability of finance, product market regulation and the supply of skilled human resources for science and technology) on R&D expenditure, innovation, and more generally on total factor productivity (Jaumotte and Pain, 2005a, 2005b). Some of these studies have drawn on Schumpeterian growth theory (Aghion and Howitt, 2002 and 2009). This theory provides a framework in which the growth effects of various policies (e.g. competition, education, financial markets, and political institutions) depend on the proximity of countries to the world technological frontier. While certain policies can have growth-enhancing effects in countries close to the world technological frontier, the effects of the same policies can be more limited in countries far from this frontier.

35. Using bivariate statistics, the subsequent paragraphs examine the relations between R&D investment and various factors that have been identified in the above literature as having an influence on R&D spending. These include the elements of the framework conditions for innovation such as the regulatory environment, openness to foreign and domestic competition, patent and access to private credit

financial markets. Finally, the relation with some characteristics of the "innovation ecosystem" will be highlighted.

Box 1: Methodology for computing the INSEAD Global Innovation Index

A number of the statistics presented in this chapter are based on the INSEAD Global Innovation Index 2009-2010.

A composite indicator

The Global Innovation Index was conceived at INSEAD as a formal model to capture the response readiness of nations and regions to the challenge and potential of innovation. This is directly linked to a country's ability to benefit from a variety of macro parameters like sophisticated technologies, enhanced human capacities, organisational and operational developments, and improved policy environment.

In its 2009/2010 version, the framework of the Global Innovation Index model rests relies on seven pillars, which underpin the factors that enhance innovative capacity and demonstrate results from successful innovation: 1) institutions; 2) human capacity; 3) ICT & uptake of infrastructure; 4) market sophistication; 5) business sophistication; 6) science outputs; and 7) creative outputs.

A key objective of the Global Innovation Index is that by looking at the overall index of a country, one can get an idea of how a country compares relative to other countries; specifically, countries facing similar global and innovation challenges. While calculating the Global Innovation Index, the overriding aim was to provide the most scientific and credible interpretation of reality. The process included selecting qualitatively relevant variables, estimating missing data, and finally, calculating the index by averaging the normalised data.

Different data sources

The model uses a combination of objective data drawn from a variety of public and private sources, such as World Bank, UNESCO, OECD, IMF, and the International Telecommunications Union, and subjective data drawn from the World Economic Forum's annual Executive Opinion Survey. The latter helps to capture concepts for which objective (or hard) data are typically unavailable. Since the model partly relies on subjective data, the results of the Global Innovation Index should be interpreted with caution. Perceptions can be different from reality.

Data normalization

Variable data is normalised in such a way that the range is from 1-7. A variable is either positively normalised or negatively normalised. A variable for which a higher absolute value indicates a good outcome was positively normalised (example: GDP per capita) whereas a variable for which a higher absolute value indicate a worse outcome was negatively normalised. Thus the process of normalisation gives a score of 7 for the best performing country and a score of 1 is for the worst performing country for a particular variable.

The formula used for normalization is:

- For positive normalization: 6 x (country score – sample minimum)/ (sample maximum – sample minimum) + 1
- For negative normalization: – 6 x (country score – sample minimum)/ (sample maximum –sample minimum) + 7

Geographic coverage

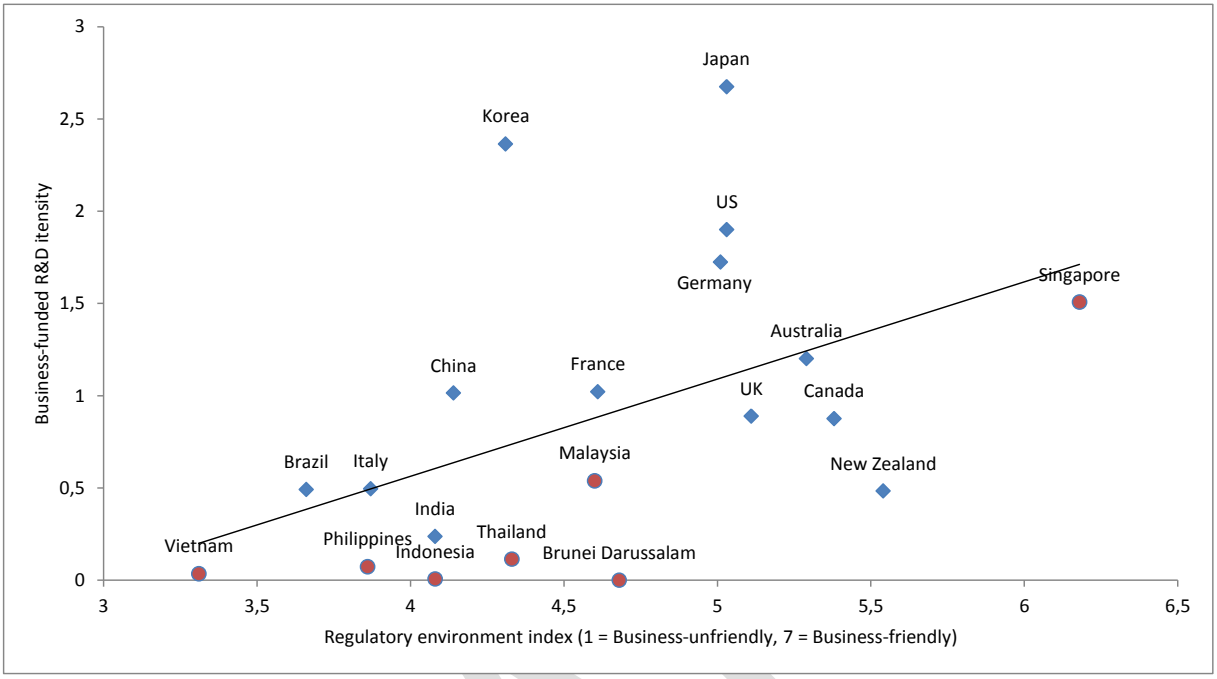
The Global Innovation Index covers 132 countries around the world.

Source: INSEAD (2010); www.globalinnovationindex.org.

3.1.2. Regulatory environment

36. Figure 13 shows the relation between business-funded R&D intensity and a regulatory environment index derived from the INSEAD Global Innovation Index 2009-2010. The index is a composite indicator made up of several variables: regulatory quality, the burden of government regulation, and the strength of auditing and reporting standards.

Figure 13: Business-funded R&D intensity versus regulatory environment index in selected countries, latest year available



Notes: For business-funded R&D intensity, the latest years available are 2008: Canada, France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam; 2001: Indonesia.

Sources: Executive Opinion Survey, World Economic Forum; INSEAD (2010); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

3.1.3. Openness to competition

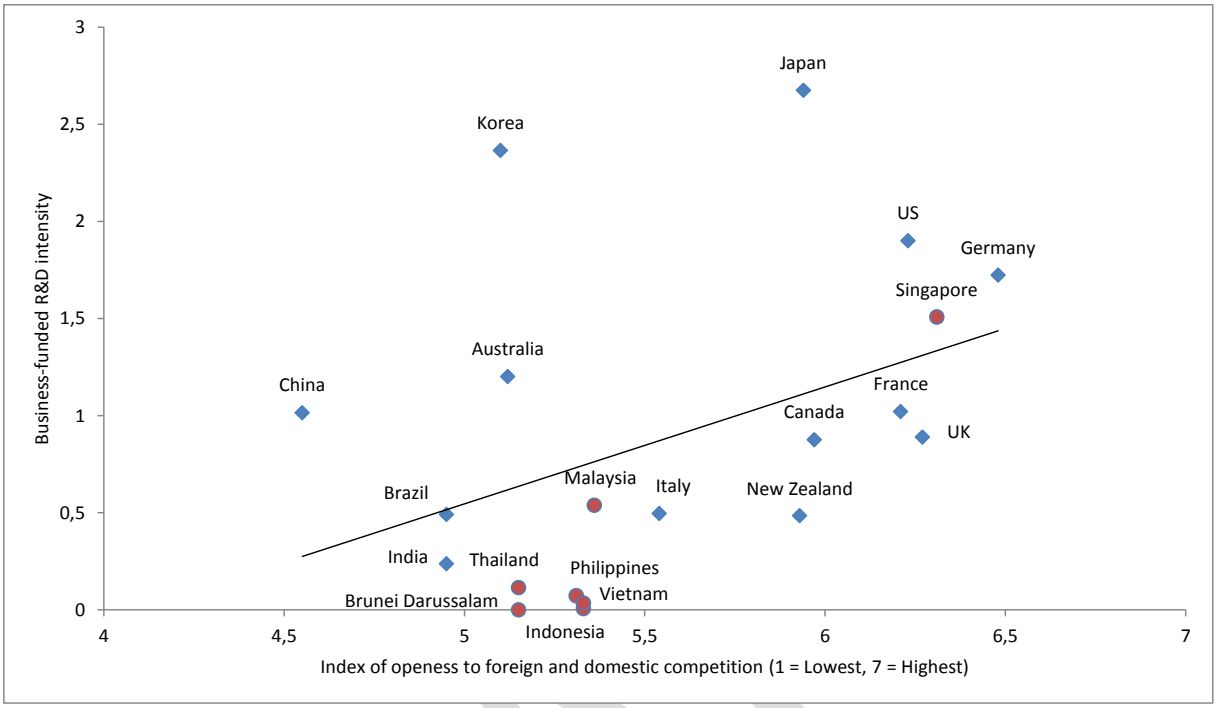
37. The index of openness to foreign and domestic competition is derived from the INSEAD Global Innovation Index 2009-2010. This is a composite indicator combining two individual indicators: the trade-weighted average tariff rate and the intensity of local competition (Table 5).

Table 5: Definition of the index of openness to foreign and domestic competition

Variable	Source	Year(s)	Definition
Trade-weighted average tariff rate	International Trade Center	2008	This indicator is calculated as the average of the applied tariff rates, including preferential rates that a country applies to the rest of the world. The trade pattern of the importing country's reference group (2007 data) is used as a weighting.
Intensity of local competition	Executive Opinion Survey, World Economic Forum	2009	How would you assess the intensity of competition in the local markets in your country? 1 = Limited in most industries, 7 = Intense in most industries

Source: INSEAD (2010).

Figure 14: Business-funded R&D intensity versus index of openness to foreign and domestic competition in selected countries, latest year available



Notes: For business-funded R&D intensity, the latest years available are 2008: Canada, France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam; 2001: Indonesia.

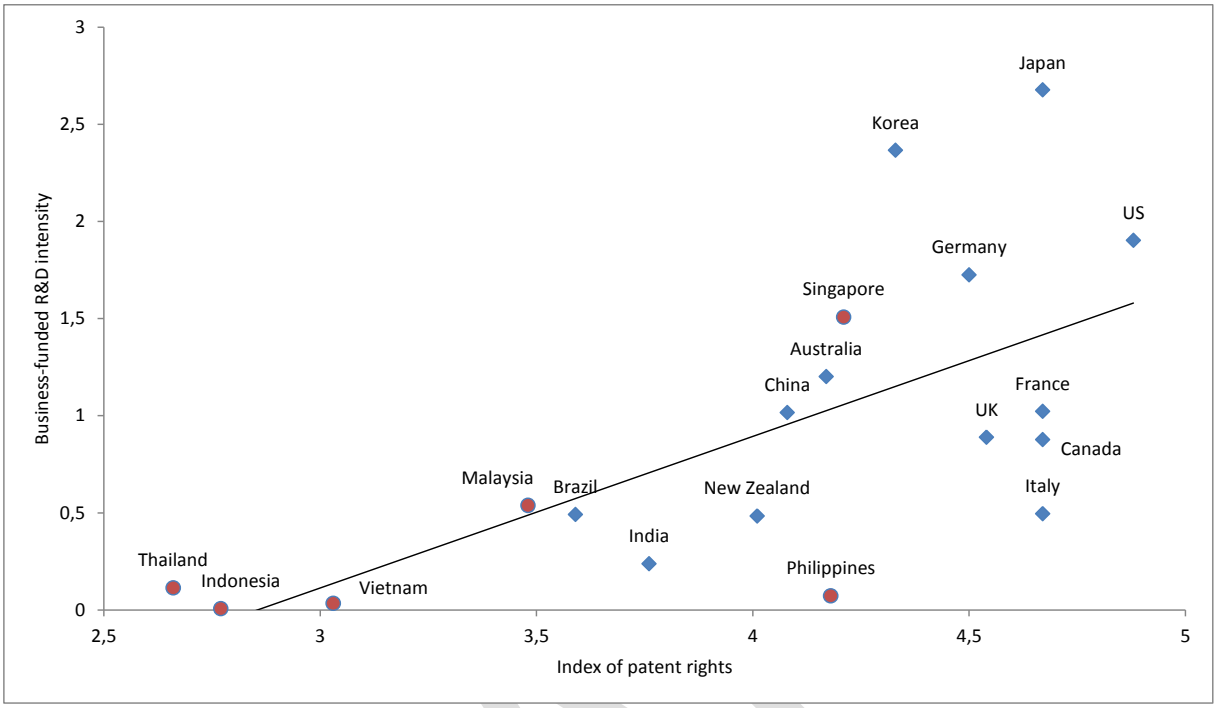
Sources: Executive Opinion Survey, World Economic Forum; International Trade Center; INSEAD (2010); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

38. The association between company spending on R&D and the index of openness to foreign and domestic competition is positive for the selected countries. The more countries open their markets to foreign and domestic competition, the higher is business-funded R&D intensity. The majority of the developed countries in North America and the European Union have opened markets to foreign and domestic competition, though their score on company spending on R&D varies. The position of Korea, Australia, and China are nevertheless particular. Although they perform well on business funded-R&D intensity, they have relative low score on the index of openness to foreign and domestic competition.

3.1.4. Patent rights

39. The association between business-funded R&D intensity and the Park's index of the strength of patent rights (Park, 2008) for the selected countries is illustrated in Figure 15. This index on the strength of patent protection is the unweighted sum of five separate indicators for: the coverage (inventions that are patentable); the membership in international treaties; the duration of protection; the enforcement mechanisms; and the restrictions (for example, compulsory licensing in the event that a patented invention is not sufficiently exploited).

Figure 15: Business-funded R&D intensity versus index of patent rights in selected countries, latest year available



Notes: For business-funded R&D intensity, the latest years available are 2008: Canada, France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam; 2001: Indonesia.

Sources: Executive Opinion Survey, World Economic Forum; INSEAD (2010); W. Park (2008); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

40. There is a positive relation between business-funded R&D intensity and the index of patent rights. Countries that perform well on business-funded R&D intensity tend to have high scores on the index of patent rights. In Southeast Asia, these countries are Singapore and to a lesser extent Malaysia.

3.1.5. Financial markets

41. The role of financial markets in facilitating R&D investment is examined through the availability of private credits for the private sector.

42. Figure 16 shows the relationship between business-funded R&D intensity and an index of access to private credit for the sample of countries. This composite index is calculated in the framework of the INSEAD Global Innovation Index 2009-2010. It is based on five individual indicators: venture capital availability, microfinance institutions – average loan balance per borrower divided by GNI per capita, financing through local equity market, domestic credit to private sector as a percentage of GDP, and foreign direct investment (net inflows) (Table 6).

43. There is a positive association between business-funded R&D intensity and the index of access to private credit. The majority of Southeast Asian countries is characterised by a difficult access to private credit and low business spending on R&D. Only Malaysia and Singapore are marked by different scores on both indicators. This is also the case for other Asian developing countries, namely China and Brazil. Reciprocally, the financial markets seem more favourable to business spending on R&D in the selected developed countries in the European Union, North America, and Asia & Pacific.

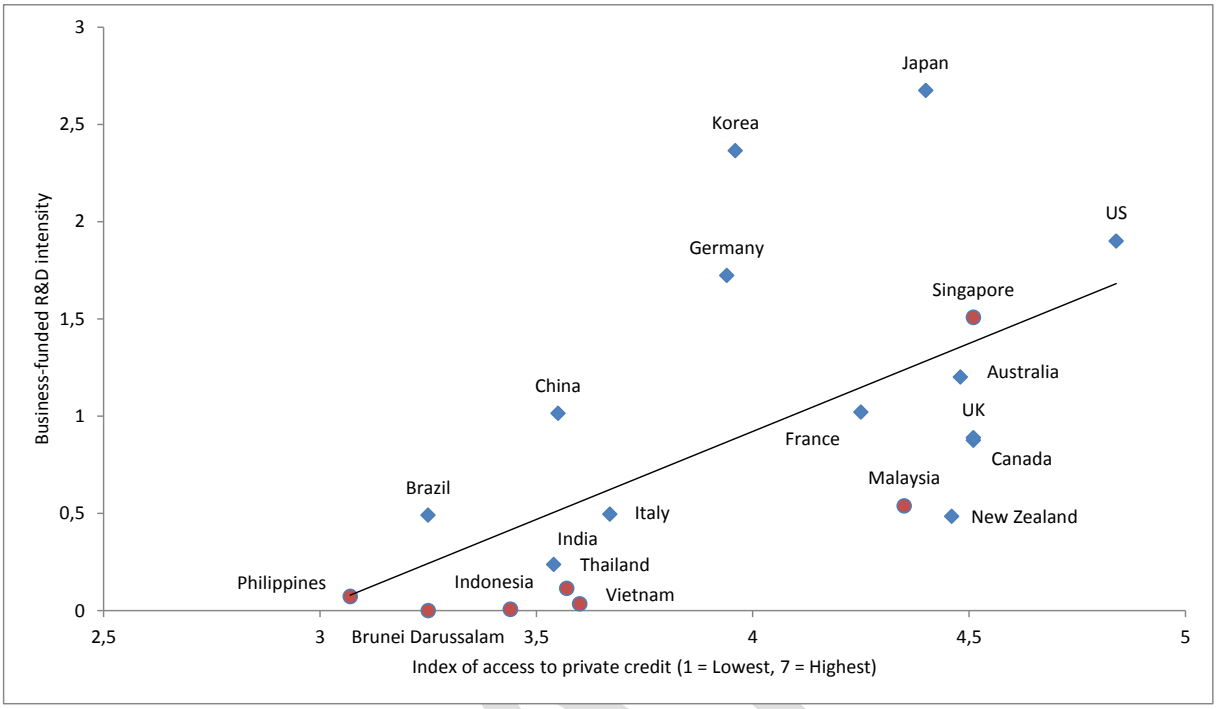
Table 6: Definition of the index of access to private credit

Variable	Source	Year(s)	Definition
Venture capital availability	Executive Opinion Survey, World Economic Forum	2009	In your country, how easy is it for entrepreneurs with innovative but risky projects to find venture capital? 1 = Very difficult, 7 = Very easy
Microfinance Institutions (MFIs) - Average loan balance per borrower / GNI per capita	Mix Market	2007 or preceding latest year available	Microfinance Institutions (MFIs) -Average loan balance per borrower / GNI per capita in microfinance institutes
Financing through local equity market	Executive Opinion Survey, World Economic Forum	2009	How easy is it to raise money by issuing shares on the stock market in your country? 1 = Very difficult, 7 = Very easy
Domestic credit to private sector as a percentage of GDP	International Monetary Fund, International Financial Statistics and data files; World Bank, World Development Indicators	2007 or preceding latest year available	Domestic credit to private sector refers to financial resources provided to the private sector, such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises.
Foreign direct investment, net inflows (BoP, Current US$)	International Monetary Fund, Balance of Payments Statistics Yearbook and data files; World Bank, World Development Indicators	2007 or preceding latest year available	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of the equity capital, reinvestment of earning, other long-term capital, and short term capitals shown in the balance of payments This series shows net inflows in the reporting economy.

Source: INSEAD (2010).

DRAFT

Figure 16: Business-funded R&D intensity versus index of access to private credit in selected countries, latest year available



Notes: For business-funded R&D intensity, the latest years available are 2008: Canada, France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam; 2001: Indonesia.

Sources: Executive Opinion Survey, World Economic Forum; Mix Market; International Monetary Fund, International Financial Statistics and Balance of Payments databases; World Bank, Global Development Finance; World Bank World Development Indicators; INSEAD (2010); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

44. Finally, we look at the relation between R&D investment and the development of innovation ecosystems the selected countries.

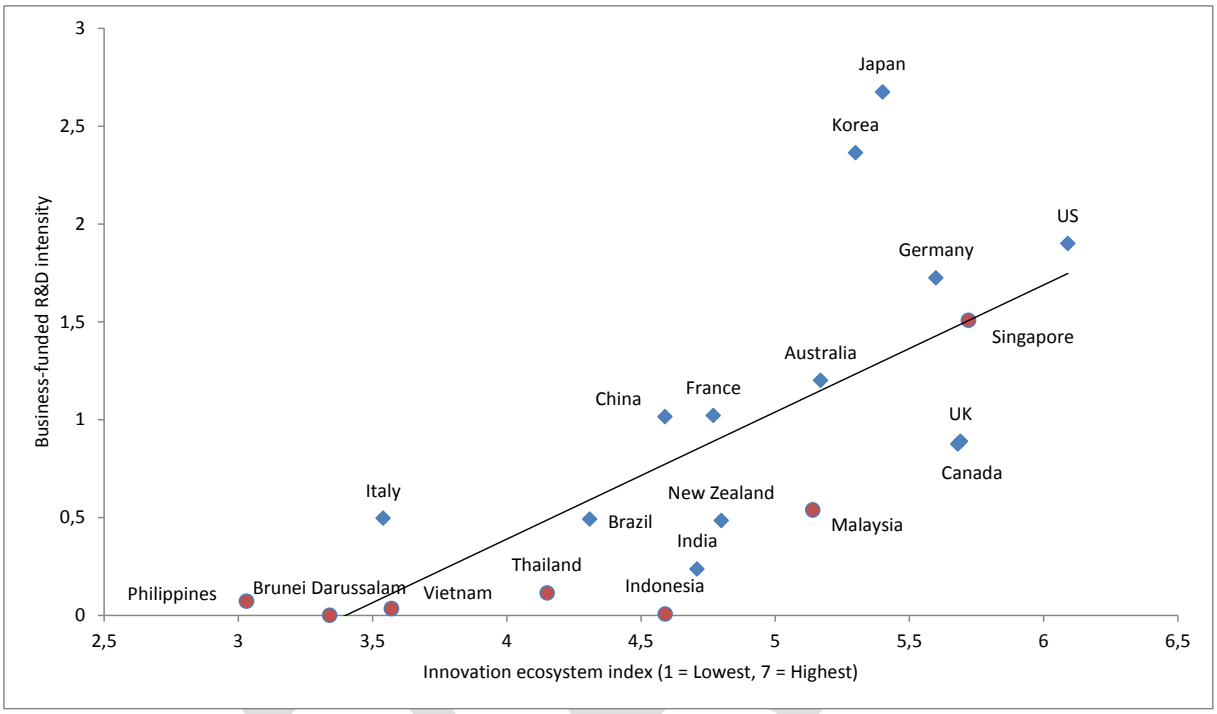
Table 7: Definition of the innovation ecosystem index

Variable	Source	Year(s)	Definition
State of cluster development	Executive Opinion Survey, World Economic Forum	2009	In your country, how extensive is collaboration among firms, suppliers, partners, and associated institutions within clusters? 1 = Collaboration is non-existent, 7 = Collaboration is extensive
University-industry collaboration	Executive Opinion Survey, World Economic Forum	2009	To what extent do business and universities collaborate on research and development (R&D) in your country? 1 = Do not collaborate at all, 7 = Collaborate extensively
Culture to innovate	Executive Opinion Survey, World Economic Forum	2009	To what extent do you feel that companies I your country have fostered a culture that expects everyone to contribute to innovation? 1 = Not at all, 5 = Definitely

Source: INSEAD (2010).

45. The development of innovation ecosystems is measured by a composite index from the INSEAD Global Innovation Index. It is based on three individual indicators: the state of cluster development, university-industry collaboration, and the innovation culture (Table 7).

Figure 17: Business-funded R&D intensity versus innovation ecosystem index in selected countries, latest year available



Notes: For business-funded R&D intensity, the latest years available are 2008: Canada, France, United Kingdom, United States; 2007: Brazil, China, Germany, India, Italy, Japan, New Zealand, Korea, Singapore; 2006: Australia, Malaysia; 2005: Thailand, Philippines; 2004: Brunei Darussalam, 2002: Viet Nam; 2001: Indonesia.

Sources: Executive Opinion Survey, World Economic Forum; INSEAD (2010); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

46. There is a clear relation between business-funded R&D intensity and the innovation ecosystem index in the sample of selected countries (Figure 17). The more innovation ecosystems are developed, the more companies spend on R&D. This is the case for Singapore and Malaysia among the Southeast Asian countries. Within the Asian region, Korea and Japan also score well on both indicators.

47. The preceding developments showed that there is a positive relation between R&D investment and various factors that have been identified in the literature as having influenced on R&D spending behaviour in the selected countries. These factors are a well-designed institutional framework, a human capital capacity, innovation-friendly financial markets, and a business environment that favours R&D and innovation. All Southeast Asian countries but Singapore and to a lesser degree Malaysia underperform on both dimensions compared to the other countries in the sample. The situation of China and India is better although these countries still fall well behind other Asian countries such as Korea and Japan. It should however be stressed that the scores of Southeast Asian countries along the different factors are not low in absolute terms. Numerous countries in poor regions of the world show a worst situation. These countries are nevertheless not considered in the analysis.

48. The analysis is however based only on bivariate statistics. These statistics ignore the relations among these factors and their impacts on R&D investment. When these relations are taken into account,

the individual impact of certain factors on R&D investment may be reduced. Furthermore, this analysis does not suggest that low- or middle-income countries should simply take over S&T policies that are in place in countries close to the world technological frontier. These policies – and their impact – are context-dependent. For instance, overly rigorous patent protection and a high stock of tertiary education can be inefficient in countries that are far from the world technological frontier although they become necessary as they close the gap to the more advanced countries. For instance, overly strong patent protection may impede international technological transfer while a high stock of tertiary education may not be needed given the nature of prevailing innovation and research processes (Fink and Maskus, 2004; Hassan, Yaqub and Diepeveen, 2010; Vandenbussche, Aghion and Meghir, 2006).

3.2. Innovation performance and competitiveness

The next developments examine some of the effects of R&D investment in the selected world regions and countries: the creation of new scientific and technological knowledge, and industrial and macro-economic performance.

3.2.1. Science and technology output

49. The creation of scientific and technological knowledge is measured by means of bibliometric indicators on the number of publications published in peer-reviewed journals and the number patents. Data on publications are extracted from the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) of Thomson Reuters.[4] Data on patents are PCT patent applications.[5]

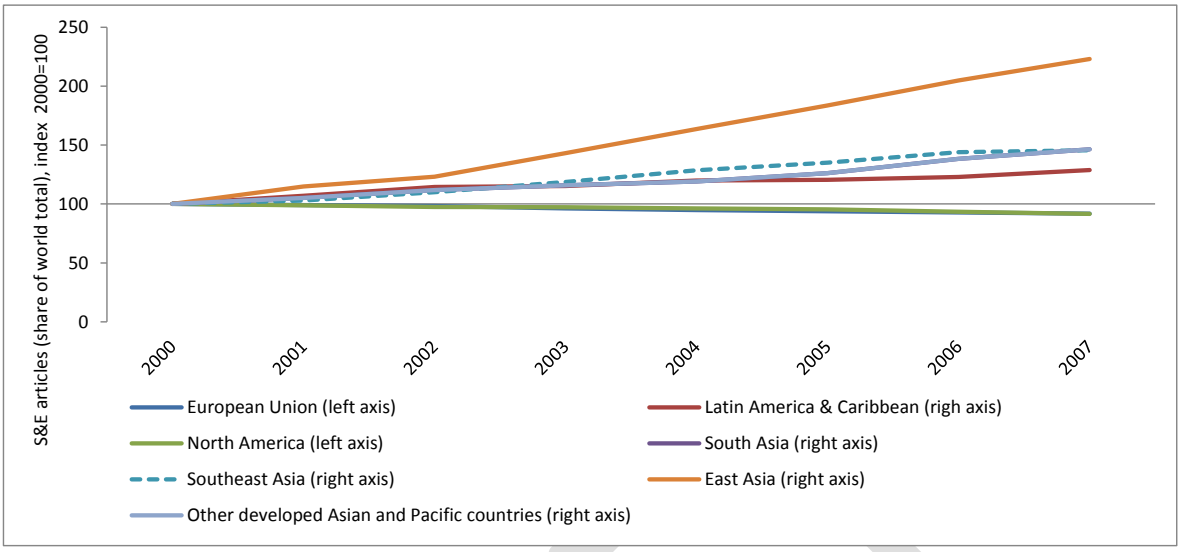
50. Figure 18 shows the growth of the S&E article output for the seven world major regions since 2000. East, Southeast, and South Asia as well as the other developed Asian and Pacific countries have increased sharply their contribution the world S&E output. With an annual growth of 11.5 per cent, the increase has been particularly strong in East Asia. The world shares of the South Asia, Southeast Asia, and the other developed Asian and Pacific countries have grown at the same pace, approximately 5.4 per cent per year.

DRAFT

[4] Data include articles, notes, and reviews. They exclude letters to the editor, news stories, editorials, and other material whose purpose is not the presentation or discussion of scientific data, theory, methods, apparatus, or experiments.

[5] The Patent Cooperation Treaty (PCT) is an international treaty, administered by the World Intellectual Property Organization (WIPO). The PCT is a system facilitating the worldwide filing of patent applications. The PCT makes it possible to seek patent protection for an invention simultaneously in each of a large number of countries (who are contracting states to the PCT) by first filing a single "international" patent application. Later, the granting of patents remains under the control of the national or regional patent Offices in what is called the “regional phase” or “national phase”.

Figure 18: Growth of the S&E article output in seven regions since 2000



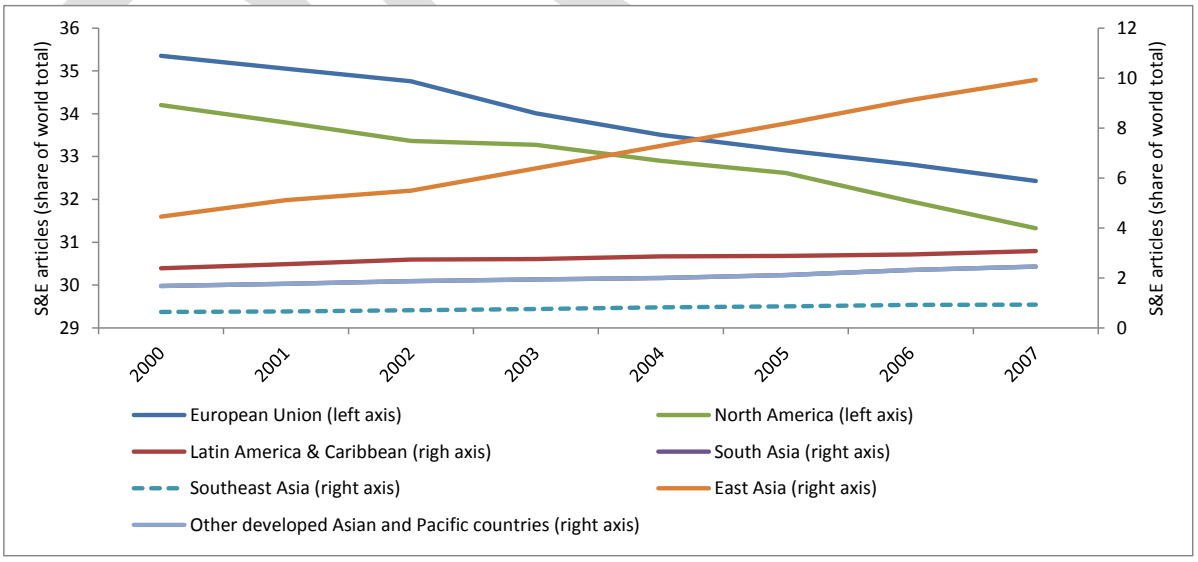
Note: Fractional counting for the number of articles.

Sources: Thomson Reuters, SCI and SSCI; National Science Foundation, Science and Engineering Indicators; World Bank World Development Indicators.

51. However, there are important disparities among the regions regarding their share in the world S&E article output, which cannot only be explained by differences in the number of inhabitants.

52. The shares of North America and the European in the world total are shown on the left axis of Figure 19 while those of the other regions are displayed on the right axis. Although the shares of North America and the European in the world total have slightly decreased since 2000, they remain well-above those of the other regions. In 2007, they amounted respectively to 32.4 and 31.3 per cent. In 2007, the share of Southeast Asia in the world S&E article output totalled 0.9 per cent, against 9.9 and 2.5 per cent for East Asia and South Asia.

Figure 19: Levels of S&E article output in seven regions since 2000



Note: Fractional counting for the number of articles.

Sources: Thomson Reuters, SCI and SSCI; National Science Foundation, Science and Engineering Indicators; World Bank World Development Indicators.

53. Looking at the sample of countries in the seven regions (Table 9), all Southeast Asian countries had world shares below 1 per cent in 2007. The Southeast Asian countries with the higher shares were Singapore, followed by Thailand and Malaysia. Among these three countries, Thailand experienced a two digits annual growth rate of its world share between 2000 and 2007. In Asia, China also enjoyed an exceptional growth of its world share during that period. The latter grew by approximately 16 per cent annually. This is twice the annual growth rate of India's world share during the same period.

Table 8: The evolution of the number of S&E journal articles in selected countries since 2000

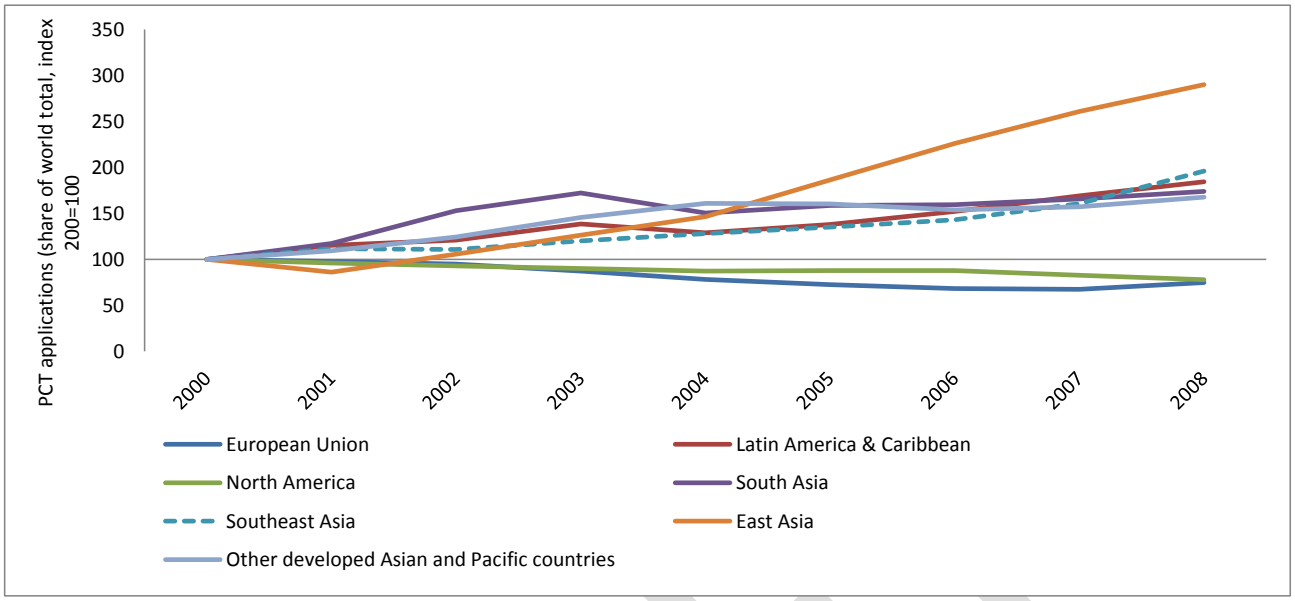
Country	2000	2007	Average annual change (%)	Percent of world total (2007)
United States	192743	209695	1,2	27,7
China	18479	56806	16,0	7,5
Japan	57101	52896	-1,1	7,0
United Kingdom	48216	47121	-0,3	6,2
Germany	43509	44408	0,3	5,9
France	31427	30740	-0,3	4,1
Canada	22701	27800	2,9	3,7
Italy	21409	26544	3,1	3,5
Korea	9572	18467	9,4	2,4
India	10276	18194	8,2	2,4
Australia	14589	17831	2,9	2,4
Brazil	6407	11885	8,8	1,6
Singapore	2361	3792	6,8	0,5
New Zealand	2851	3173	1,5	0,4
Thailand	663	1728	13,7	0,2
Malaysia	460	808	8,1	0,1
Vietnam	147	283	9,4	0,0
Indonesia	182	198	1,2	0,0
Philippines	185	195	0,8	0,0
Chinese Taipei	16	46	15,1	0,0
Cambodia	6	26	21,9	0,0
Brunei Darussalam	22	16	-4,5	0,0
Myanmar	7	13	8,7	0,0
Lao PDR	4	12	16,4	0,0

Note: Fractional counting for the number of articles.

Sources: Thomson Reuters, SCI and SSCI; National Science Foundation, Science and Engineering Indicators.

54. Figure 20 presents the growth of the PCT patent application output for the seven world regions since 2000. The share of all regions but North America and the European Union has followed an upward trend. Growth has been particularly high in East and Southeast Asia.

Figure 20: Growth of the PCT patent applications since 2000 in seven regions



Note: Fractional counting for the number of PCT patent applications. Counting by priority date and Inventor(s)'s country(ies) of residence.

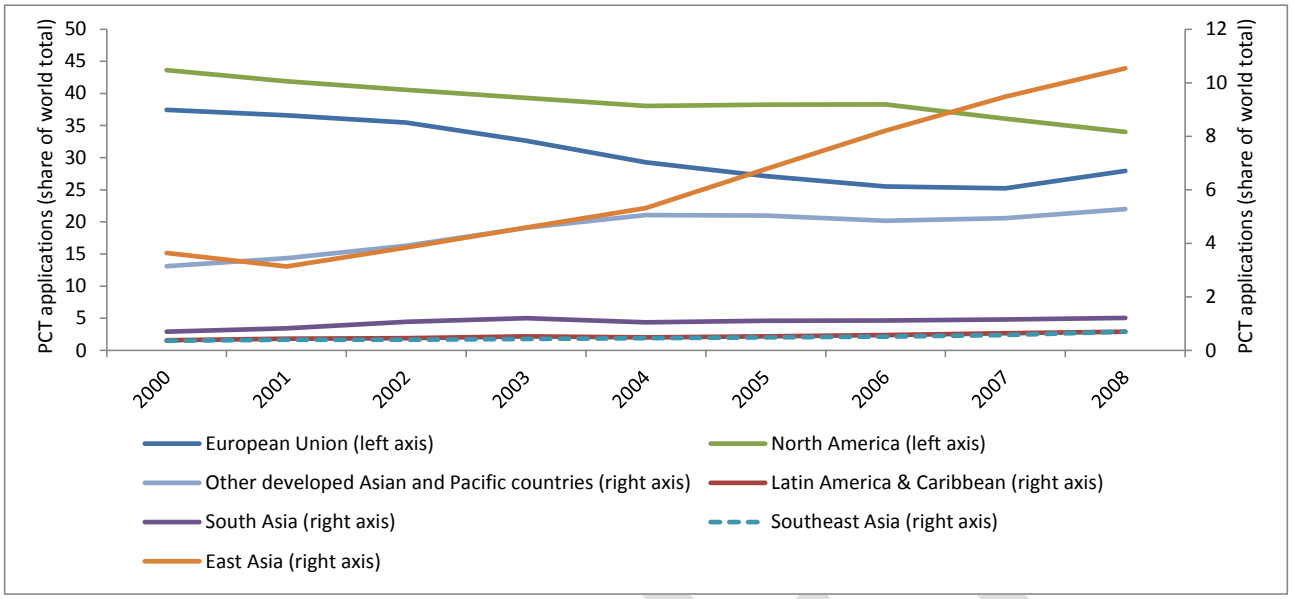
Sources: OECD Patent Database.

55. Despite this performance of the developing regions since 2000, their share in the world technological output has remained well-below that of developed regions. Figure 21 shows the shares of North America and the European in the world total are shown on the left axis while those of the other regions are displayed on the right axis.

56. The world output over the period was principally fuelled by US and EU inventors and those in the other developed Asian and Pacific countries. The shares of US and EU inventors nevertheless showed a downward trend over from 2000 and 2008 while the share of inventors in the other developed Asian and Pacific countries increased.

57. In 2008, the shares of US and EU inventors in PCT patent application output were, respectively 34 and 27.9 per cent; the share of inventors in the other developed Asian and Pacific countries picked up to 22 per cent. The contribution of inventors in Southeast and Southern Asian countries remained very low over that period. Conversely, the output of East Asian inventors increased at the annual rate of 13.3 per cent over the period to reach 10.5 per cent of the world total in 2008.

Figure 21: Levels of the PCT patent application output in seven regions since 2000



Note: Fractional counting for the number of PCT patent applications. Counting by priority date and Inventor(s)'s country(ies) of residence.

Sources: OECD Patent Database.

58. An examination of the evolution of the number of PCT patent applications across the selected countries in the seven world countries reveals that the most dynamic Southeast Asian countries are Singapore and Malaysia (Table 10). Not only did they have the highest world shares in Southeast Asia in 2008 but they also experienced high growth in the number of their PCT patent applications from 2000 to 2008. In Asia, Japan, Korea, and China were the countries with the highest number PCT patent applications in 2008. Such number also increased substantially over the period. India only ranked above Singapore in 2008 despite a sustained growth of its PCT patent applications over the period.

DRAFT

Table 9: The evolution of the number of PCT patent applications in selected countries since 2000

Country	2000	2008	Average annual change (%)	Percent of world total (2008)
United States	40834	42470	0,5	29,3
Japan	10895	27019	11,4	18,6
Germany	13313	16311	2,5	11,3
Korea	1963	7034	15,9	4,9
China	1571	6792	18,3	4,7
France	4693	6712	4,5	4,6
United Kingdom	5808	5672	-0,3	3,9
Italy	1822	3026	6,3	2,1
Canada	2244	2525	1,5	1,7
Australia	1753	1791	0,3	1,2
India	268	1247	19,2	0,9
Singapore	265	627	10,8	0,4
Brazil	177	529	13,7	0,4
New Zealand	308	302	-0,3	0,2
Malaysia	43	234	21,2	0,2
Chinese Taipei	50	116	10,5	0,1
Thailand	28	33	2,4	0,0
Philippines	17	32	7,9	0,0
Indonesia	20	13	-5,3	0,0

Note: Patent counts are based on the priority date, the inventor's country of residence and use fractional counts on PCT filings at international phase

Source: OECD Patent Database.

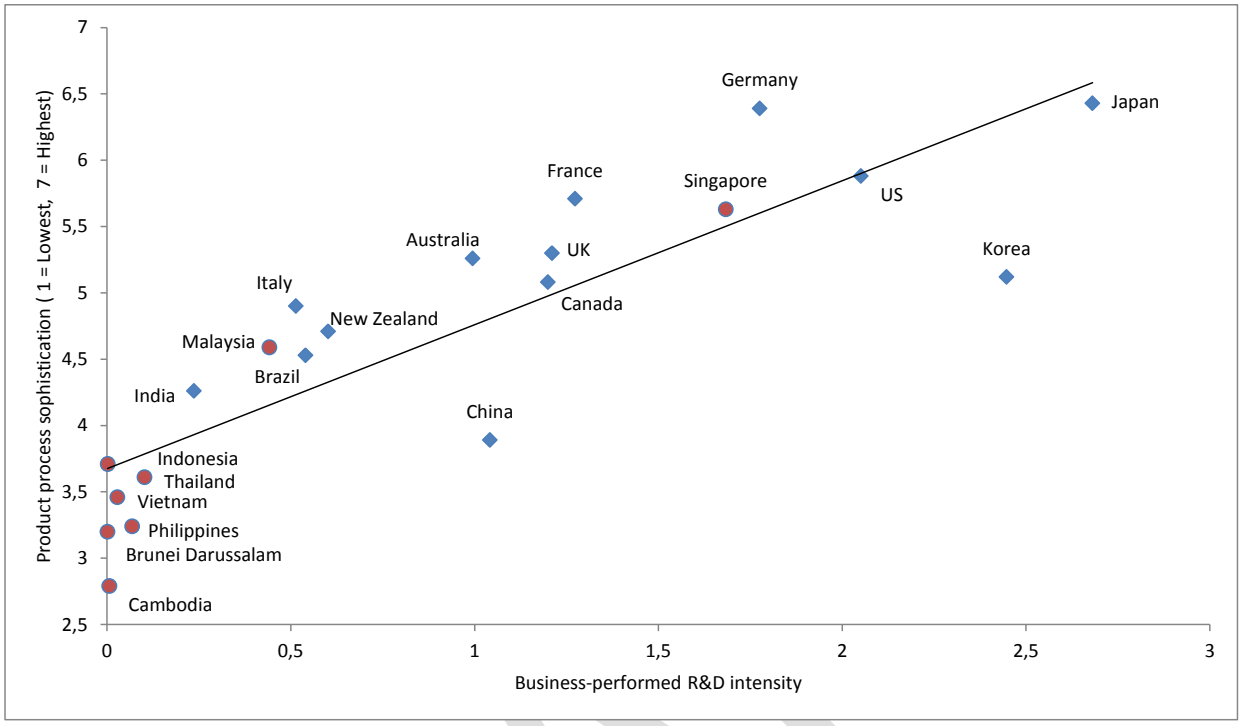
3.2.2. Industrial and macro-economic performance

59. The majority of developing countries in these regions use labour-intensive methods or previous generations of process technology rather in their production process, as reveals by the 2009 Executive Opinion Survey of World Economic Forum and the results to its question on product process sophistication.[6]

60. The use of more efficient process technology is positively correlated with business-performed R&D intensity (Figure 22). Among the Southeast Asian countries, Singapore and Malaysia show the highest business-performed R&D intensity and the use of the most efficient product process technology.

[6] In your country, how sophisticated are production processes? 1 = Not at all - labour-intensive methods or previous generations of process technology prevail, 7 = Highly - the world's best and most efficient process technology prevails.

Figure 22: Product process sophistication versus business-performed R&D intensity in selected countries, latest year available

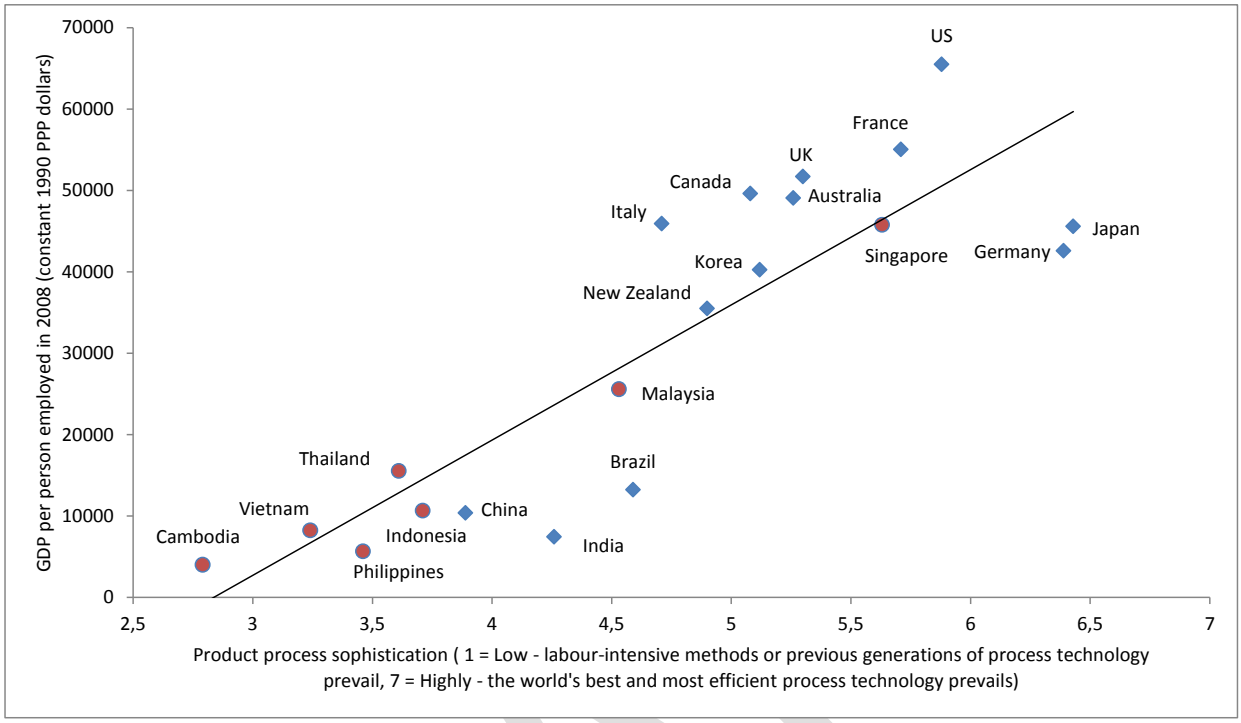


Notes: For business-performed R&D intensity, the latest years available are 2008: Canada, France, Italy, United Kingdom, United States; 2007: Singapore, New Zealand, Korea, Japan, China; Germany, Brazil, India; 2006: Australia, Malaysia, Thailand, 2005: Indonesia, Philippines; 2004: Brunei Darussalam, 2002: Cambodia, Viet Nam.

Sources: Executive Opinion Survey, World Economic Forum; INSEAD (2010); United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics; OECD.

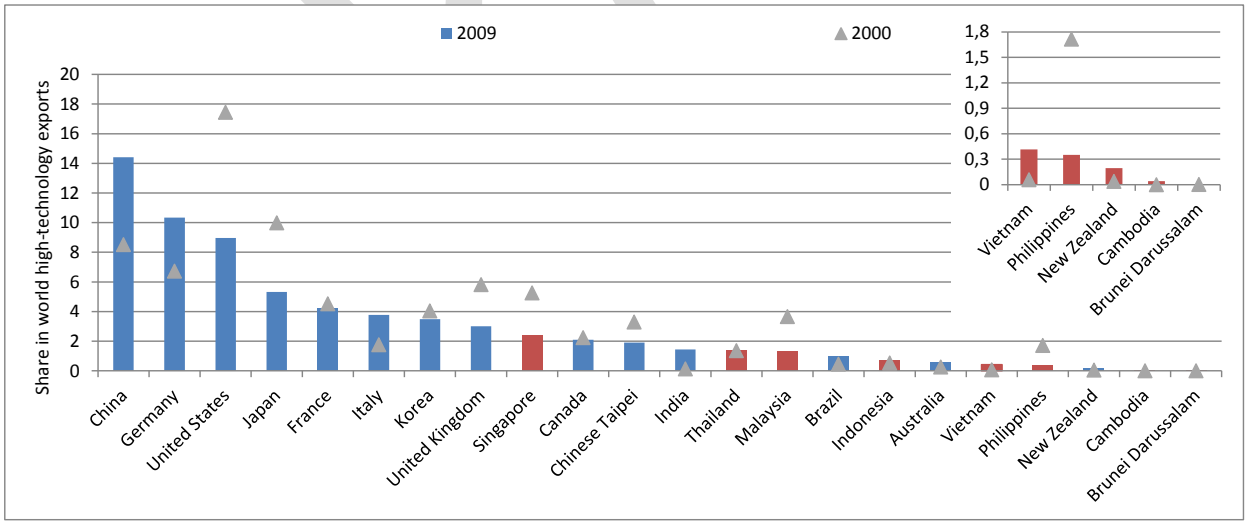
61. The use of labour-intensive methods or previous generation of process technology can provide an explanation for the current low levels of labour productivity in many Southeast Asian countries despite the rapid growth in their output per worker over the past three decades. Figure 23 illustrates the relation between product process sophistication in the sample of countries and the level of GDP per person employed in 2008. The relation between these two indicators is positive. The more countries use the world's best and most efficient process technology, the higher the levels of output per person employed are.

Figure 23: Level of labour productivity versus product process sophistication versus in selected countries, latest year available



Sources: International Labour Organization, Key Indicators of the Labour Market database; World Bank World Development Indicators; Executive Opinion Survey, World Economic Forum; INSEAD (2010).

Figure 24: High-technology exports in world high-technology manufacturing exports, 2000 and 2009



Note: The World high-technology exports total is estimated based on the sum of the high-technology exports of the reporting countries in the OECD Bilateral Trade Database; Value in current dollars.

Source: OECD Bilateral Trade Database.

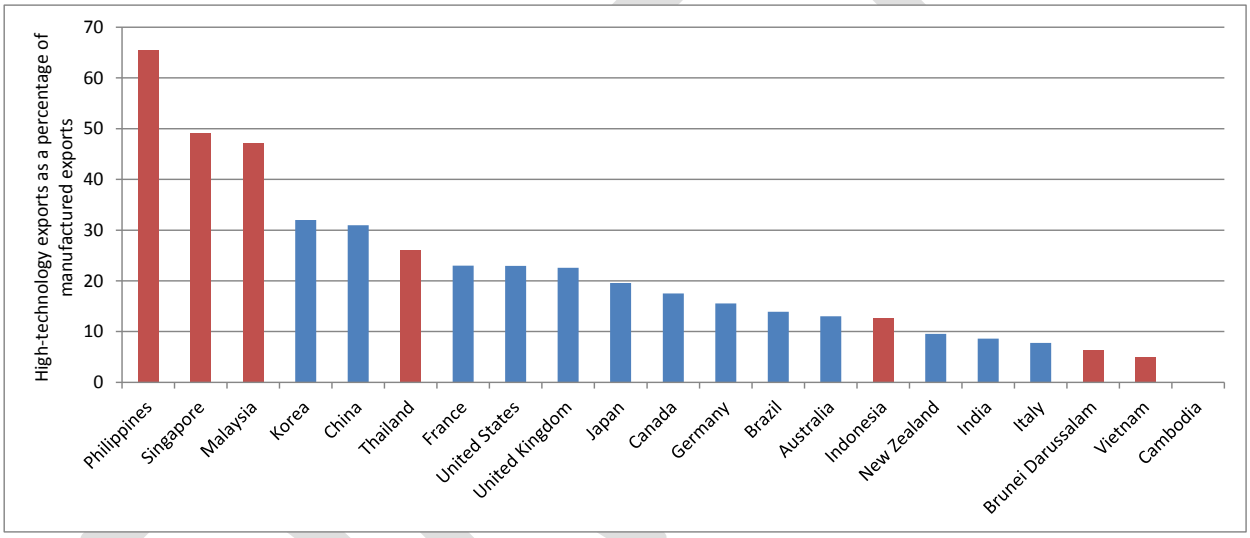
62. The success of countries in exporting their high-technology goods on the global markets is another measure of their innovation performance. Figure 24 shows the share of countries in the different

regions in the world high-technology exports in 2000 and 2009. Most of the Southeast Asian countries but Singapore exhibit the lowest world shares in high-technology manufacturing exports in 2009.

63. While this underperformance can reflect a size effect, it should be noted that these shares substantially decreased in Singapore, Malaysia, and the Philippines from 2000 to 2009. The decline of their competitive advantage is not specific to Southeast Asian countries as the world share of Japan and many other advanced countries also shows a downward trend. It can be explained by the sharp competition from other Asian countries, notably China, which improve their position in the global high-technology markets during the last decades.

64. These trends also reflect changes in the global and regional value chains of ICT and electronics industries, which constitute a significant part of Southeast Asian high-technology exports. Southeast Asian countries have indeed established themselves as key players in the global and regional value chains of ICT products and electronics

Figure 25: High-technology exports of selected countries, latest year available



Source: United Nations, Comtrade database; World Bank Development Indicators; OECD.

65. Nonetheless the majority of these countries with the notable exception of Singapore is involved in ICT and electronic segments that are relatively standardised and with low value-added (Wattanapruttipaisan, 2007).[7] China is a treat for Southeast Asian and other Asian countries on these low value-added segments due to low labour costs (Eichengreen, Rhee and Tong, 2004). Currently China is importing more high-technology products from Southeast Asian products to re-export on global markets without adding a substantial share of domestic value-added (Koopman, Wang and Wei, 2008). However China is likely to climbs the value chain and become a threat for other more advanced Asian countries on integrated production systems (Lall and Abaladejo, 2004).

66. This decline of the competitive advantage of several Southeast Asian countries on the global high-technology trade is particularly damageable because exports from these countries are largely high-technology ones (Figure 25). The share of high-technology exports in manufacturing exports is indeed higher than 45 per cent in the Philippines, Singapore, and Malaysia. Consequently Southeast Asian

[7] This is corroborated by Figure 23, which shows that most of the Southeast Asian countries use labour-intensive methods or previous generation of process technology.

countries have also to climb the value chain by developing products with more value-added for the global market. Climbing the global value chain will nevertheless require more commitments to R&D and innovation.

67. This section presented patterns in R&D investment and innovation performance in the seven world regions and the sample of countries. Its findings show that R&D investment is the highest in the developed Asia & Pacific, North American, and EU regions. The other regions are lagging behind, though there are wide cross-country differences. R&D intensity is the highest among East Asian countries while the Southeast and Southern Asian ones tend to fall behind. These patterns reflect the differences in the standard of living among regions and in the catching-up process. In particular, relative low R&D investment does not necessarily hamper rapid catching-up in countries far from the world technological frontier. However, the more these countries are moving towards advanced economies, the more R&D and innovation will become primordial for long-run growth.

68. Countries with the highest R&D investment tend to show a well-designed institutional framework, a high human capital capacity, and innovation-friendly markets and business environment. These conditions are nevertheless context-dependant, implying that they seem to be appropriate in countries that are already close the world technology frontier. They may not all be crucial in countries far from the technological frontier.

69. Regional differences in R&D investment are reflected in the innovation and macro-economic performance of regions and in their competitive advantage on global high-technology markets. Nevertheless, several countries in Southeast Asia have improved their position in terms of science and technology output over the recent years. Increasing innovation performance is critical for these countries to improve their labour productivity and to climb the value chain on global high-technology markets, especially in the context of the rising competition from China and India.

70. Previous developments on innovation investment and performance concentrated on individual regions and countries. Nevertheless science and technology linkages between countries and regions should be considered because they are important sources of international spillovers. Consequently they can contribute to raise the standard of living of regions and countries. A rich literature has investigated the international diffusion of science and technology through various channels – including, foreign direct investment, trade, scientific and technological collaborations – and its impacts on the innovation investment and performance of countries and their productivity growth. Notwithstanding issues related its measurement, there are signs of positive international knowledge spillover effects (Coe and Helpman, 1995; Guellec and Pottelsberghe de la Potterie, 2001a; Keller, 2010; Lee 2006; Van Pottelsberghe de la Potterie and Lichtenberg, 2001).

4. Integration of the Southeast Asian region

71. This section focuses on the integration of the Southeast Asian region as a regional area for science, technology, and innovation. It first examines science and technology linkages among Southeast Asian countries. It then analyses the position of the Southeast Asian regions in science and technology networks at the global level.

4.1. Knowledge flows within Southeast Asia

72. Science and technology knowledge flows among Southeast Asian countries are traced through two different channels: science and technology collaborations, on the one hand, and, on the other hand, high-technology trade.

4.1.1. Disembodied knowledge flows

73. Scientific co-operations among Southeast Asian countries are measured using bibliometric data on international co-publications. Table 11 shows the number of these co-publications during the first half of the past decade. All the Southeast Asian countries for which data is involved were interconnected through co-publications. The strength of the ties among these countries nevertheless varies. Indonesia had for main scientific partners Malaysia and to a lesser extent Thailand. Malaysia collaborated actively with Thailand, Singapore and to a lesser degree with Indonesia. The Philippines had the strongest ties with Thailand. Singapore co-operated actively with Malaysia. Finally, the main scientific partner of Viet Nam was Thailand.

Table 10: Number of international co-publications among Southeast Asian countries, 2000-2004

Partner country \ country	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Indonesia	0	102	51	61	84	43
Malaysia	102	0	50	163	183	23
Philippines	51	50	0	50	91	35
Singapore	61	163	50	0	101	33
Thailand	84	183	91	101	0	96
Vietnam	43	23	35	33	96	0

Note: International co-publications counts use simple counts.

Sources: Thomson Reuters, SCI, SSCI, A&HCI, CPCI-S; B. Scheidt, D. Tunger, S. Haustein, and C. Holzke (2010).

74. The structure of the scientific network in Southeast Asia slightly changed between 2005 and 2009. The strength of scientific collaborations among Southeast Asian countries also increased. Indonesia's main scientific partner became Thailand, followed by Malaysia. Malaysia substantially increased its scientific collaboration with Singapore. Thailand reinforced its scientific linkages with Malaysia.

Table 11: Number of international co-publications among Southeast Asian countries, 2005-2009

Partner country \ country	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Indonesia	0	249	110	108	282	71
Malaysia	249	0	142	473	467	74
Philippines	110	142	0	144	176	89
Singapore	108	473	144	0	259	66
Thailand	282	467	176	259	0	220
Vietnam	71	74	89	66	220	0

Note: International co-publications counts use simple counts.

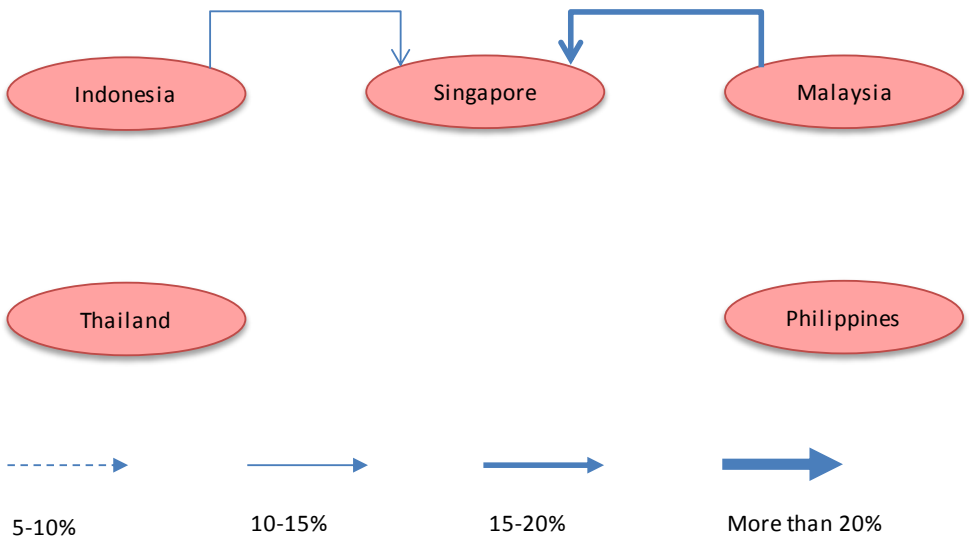
Sources: Thomson Reuters, SCI, SSCI, A&HCI, CPCI-S; B. Scheidt, D. Tunger, S. Haustein, and C. Holzke (2010).

75. International technological co-operations among Southeast Asian countries are measured by means of data on patents involving inventors with different countries in the region.[8] Compared to the structure of the scientific network in the first half of the 2000s, the technological network among Southeast Asian countries was less dense (Figure 26).Singapore had a central role in Southeast Asian technological

[8] The use of patents involving inventors from different countries is a measure of international technological collaboration used in the literature. For instance, see, Guellec and Van Pottelsberghe de la Potterie (2001b).

collaborations. For instance, it was involved in 15-20 per cent of the total of Malaysia's international co-inventions. Singapore also participated in 10-15 per cent of the total of Indonesia's intentional co-inventions. However most of the selected Southeast Asian countries collaborated with technological partners outside the region.

Figure 26: PCT patent applications with co-inventor(s) in the region, 1999-2003

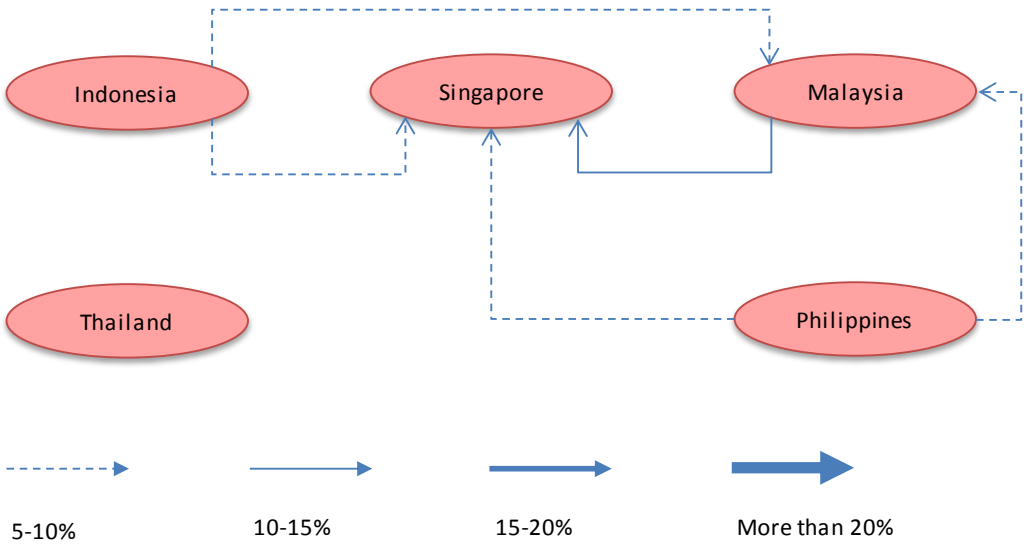


Note: Each arrow indicates that the partner's share of a country's total co-patents with abroad is equal or greater than 5 per cent. For instance, Singapore's inventors were involved in 15-20 per cent of total Malaysia's PCT patents applications with foreign co-inventors. Patent counts are based on the priority date, the inventor's country of residence and use simple counts on PCT filings at international phase. Only Southeast Asian countries with the highest number of PCT applications over the period are shown.

Source: OECD Patent Database.

76. The structure and strength of the technological collaborations among Southeast Asian changed slightly during the second half of the past decade (Figure 27). Singapore reinforced its position as a regional technological partner. It was involved in 5-10 per cent of the total of Indonesia's and Philippines' international co-inventions. Singapore also participated in 10-15 per cent of the total of Malaysia's international co-inventions. Malaysia emerged as a technological collaboration for Indonesia and the Philippines. Its share in the total of Indonesia's and Philippines's international co-inventions amounted to 5-10 per cent during 2004-2008. Despite an increase in the density of the network in the region, most of the international co-inventions involved foreign inventors outside Southeast Asia.

Figure 27: PCT patent applications with co-inventor(s) in the region, 2004-2008



Note: Each arrow indicates that the partner's share of a country's total co-patents with abroad is equal or greater than 5 per cent. For instance, Singapore's inventors were involved in 10-15 per cent of total Malaysia's PCT patents applications with foreign co-inventors. Patent counts are based on the priority date, the inventor's country of residence and use simple counts on PCT filings at international phase. Only Southeast Asian countries with the highest number of PCT applications over the period are shown.

Source: OECD Patent Database.

4.2.2. Embodied knowledge flows

77. The diffusion of embodied technology among the Southeast Asian countries is analysed by means of data on high-technology exports and imports.[9]

78. As shown by Figure 28, Singapore and Malaysia were the main exporters of high-technology goods to Southeast Asian countries during the past decade. The other Southeast Asian countries for which data is available had only a secondary role as regional exporters of high-technology products.

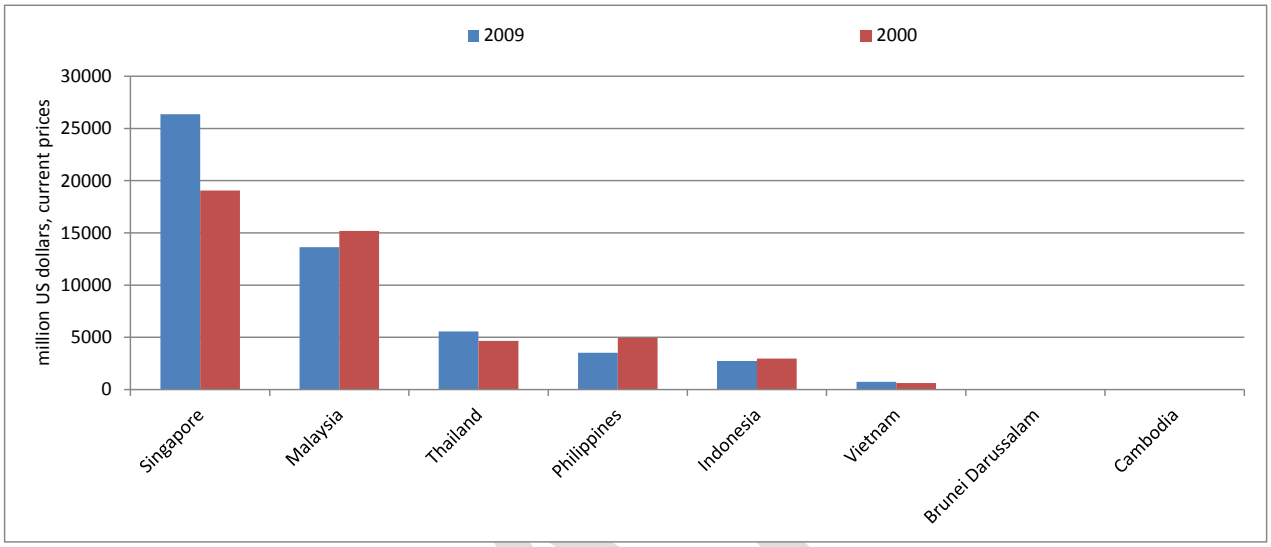
79. Figure 29 provides information on the flows of high-technology exports among these countries in 2000. The majority of Southeast Asian countries for which data is available directed more than two-thirds of the high-technology exports to countries outside the Southeast Asian region. Only Viet Nam and Cambodia exported a substantial share of their high-technology exports to other Southeast Asian countries.

80. Within the region, countries had one or two major partners only. Singapore was a major partner for Indonesia, the Philippines, Thailand, and Malaysia. Its share in Malaysian and Indonesian high-technology exports totalled 20-30 per cent; it amounted to 10-20 per cent in Thailand's and Philippines' high-technology exports. Although to a lesser degree, Malaysia had a central position in the flows of high-technology exports within the region, particularly for Singapore, Indonesia, Thailand, and Viet Nam. Other countries had a less central position in Southeast Asia, though they were strategic partners for one or two

[9] The analysis does not address the issue of the integration of Southeast Asia as a trade region. On this issue, see OECD (2010c), particularly Chapter 3. The analysis focuses instead on the integration of Southeast Asia as a regional area for science, technology, and innovation.

countries. Thailand was a main partner for Cambodia and to a lesser extent Viet Nam. The Philippines was also a strategic destination for Viet Nam's high-technology exports. Finally some countries were did not play a significant role as trade partners for Southeast Asian high-technology exports. These included Indonesia, Viet Nam, Brunei Darussalam, and Cambodia.

Figure 28: High-technology exports from selected Southeast Asian countries to Southeast Asia, 2000 and 2009



Note: Southeast Asia refers to Singapore, Malaysia, Thailand, the Philippines, Indonesia, Viet Nam, Brunei Darussalam, and Cambodia.

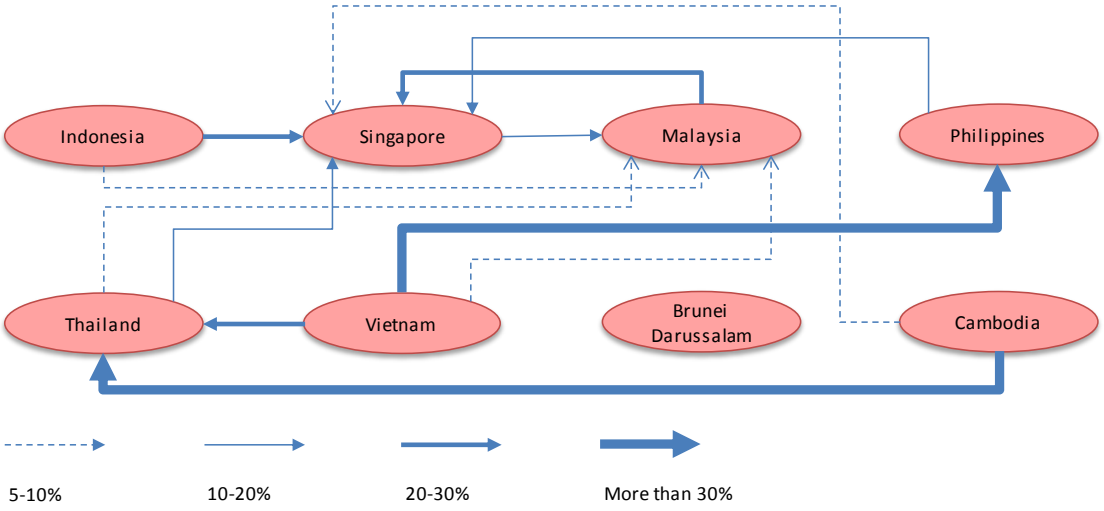
Source: OECD Bilateral Trade Database.

81. The preference of the Southeast Asian countries to export high-technology products outside the region did not decrease in 2009, as shown by the strength of the ties among them (Figure 30). However the structure of the flows of high-technology exports experienced changed.

82. Singapore was still a central actor in these flows of high-technology exports, although the strength of its ties with Malaysia and Thailand decreased. Its ties with Brunei Darussalam and Cambodia nevertheless strengthened and remained high with Indonesia. The central position of Malaysia as a regional partner somewhat declined. In 2009, it did not show up a major regional partner for Indonesia, Thailand, and Viet Nam. Thailand and the Philippines recorded a drop of their share, respectively, in Cambodia's and Viet Nam's high-technology exports. While Cambodia and Brunei Darussalam remained insignificant trade partners for other Southeast countries, the position of Indonesia and Viet Nam in the flows of high-technology exports changed slightly. The share of Indonesia in the high-technology exports of Brunei Darussalam rose substantially, reaching between 10-20 per cent. Viet Nam also became a market for Cambodia's high-technology exports, although its share in the latter was low.

83. Looking at the high-technology imports from Southeast Asia to the selected countries in the region reveals that Singapore and to a lesser degree Malaysia were the biggest importers of high-technology goods during the previous decade. Figure 32 provides further information on the flows of high-technology imports within the Southeast Asian region in 2000. Most of the Southeast Asian countries for which data is available imported their high-technology products mainly from countries outside the region.

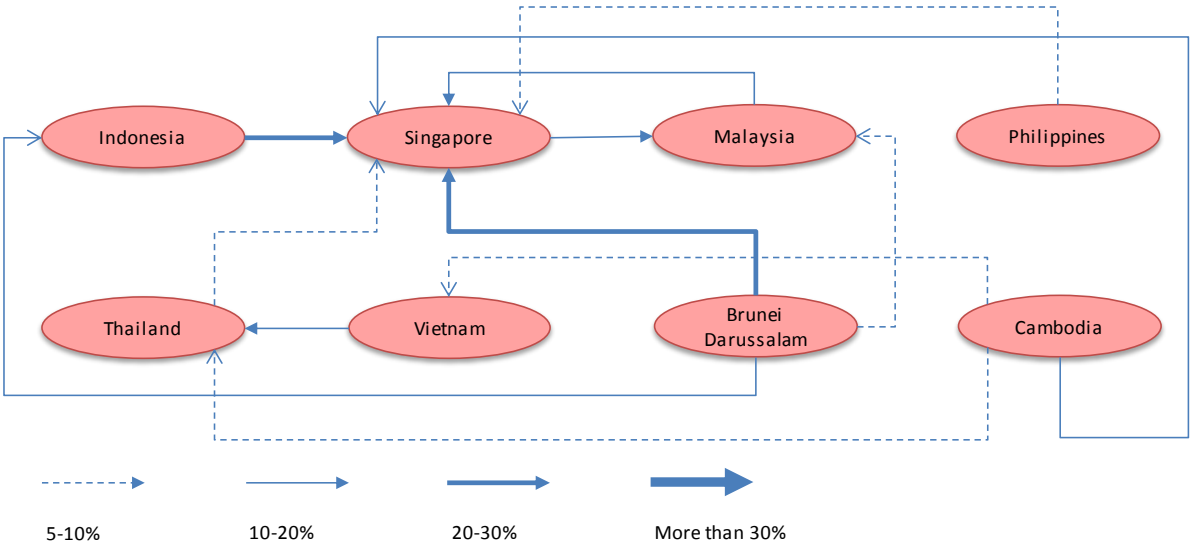
Figure 29: Major trade partners for Southeast Asian high-technology exports in Southeast Asia, 2000



Note: Each arrow indicates that the partner's share of a country's total high-technology exports is equal or greater than 5 per cent. For instance, more than 30 per cent of Cambodia's high-technology exports are directed towards Thailand. Data is based on current dollars.

Source: OECD Bilateral Trade Database.

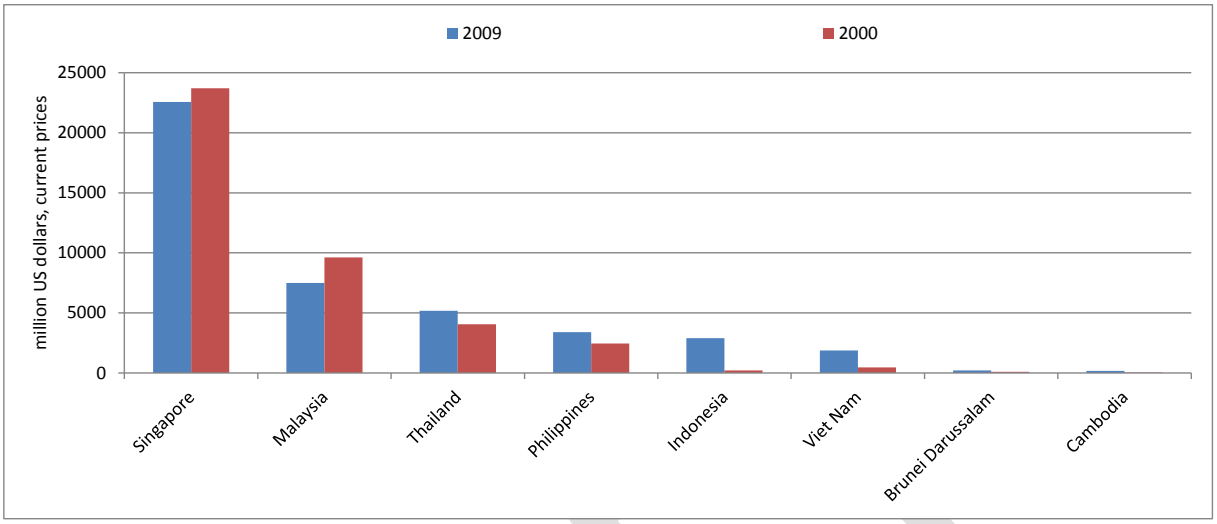
Figure 30: Major trade partners for Southeast Asian high-technology exports in Southeast Asia, 2009



Note: Each arrow indicates that the partner's share of a country's total high-technology exports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Indonesia's high-technology exports are directed towards Singapore. Data is based on current dollars.

Source: OECD Bilateral Trade Database.

Figure 31: High-technology imports from Southeast Asia to selected Southeast Asian countries, 2000 and 2009



Note: Southeast Asia refers to Singapore, Malaysia, Thailand, the Philippines, Indonesia, Viet Nam, Brunei Darussalam, and Cambodia.

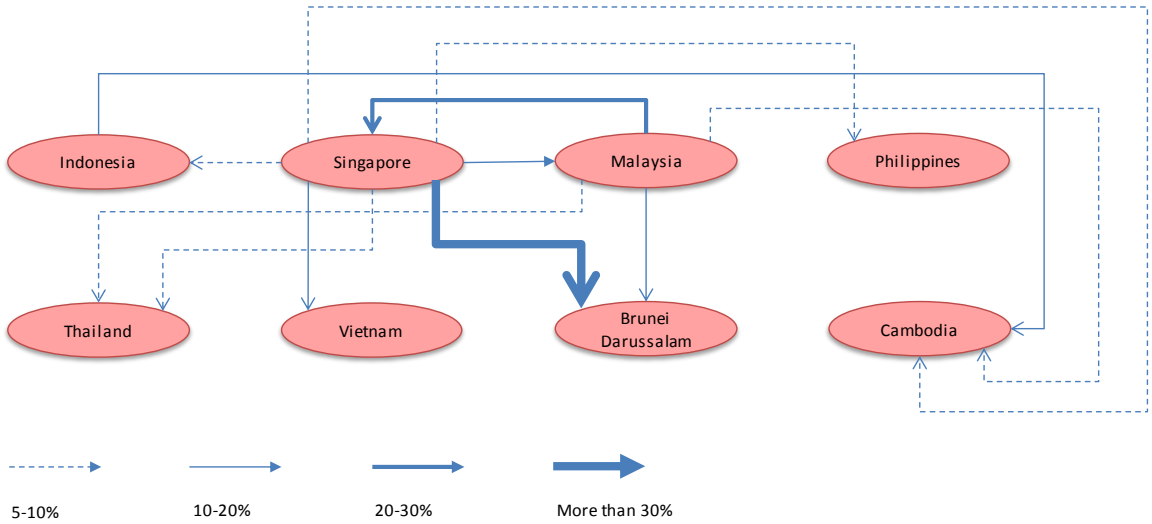
Source: OECD Bilateral Trade Database.

84. With the notable exception of Cambodia, the majority of countries imported their high-technology in Southeast Asia from one or two partners. Singapore imported 20-30 per cent of its high-technology products from Malaysia. The share of the former in Malaysia's high-technology imports was also substantial, amounting to 10- 20 per cent. In the region, Singapore and to a lesser extent Malaysia were major partners for all the Southeast Asian countries. For instance, the share of both Singapore and Malaysia in the high-technology imports of Brunei Darussalam was more than 40 per cent in 2000. All the other Southern Asian countries but Indonesia did not act as major partners for high-technology imports in the region. The share of Indonesia in Cambodia's total high-technology imported amounted to 10-20 per cent.

85. The dependence of Southeast Asian countries on other regions for their high-technology imports remained comparable in 2009 (Figure 33). Moreover, the structure of the flows of high-technology imports did not change considerably. Only the strength of the ties changed significantly.

86. Singapore reinforced its position as a strategic partner for several Southeast Asian countries. Its share in the total high-technology imports of Indonesia, Philippines, and Cambodia increased. Conversely, the position of Malaysia in the region eroded. Its share in Singapore's, Cambodia's, and Thailand's high-technology imports declined. However both Singapore and Malaysia maintained a high share in Brunei Darussalam. Finally, the share of Thailand in Cambodia's high-technology imports rose and while that of Indonesia dropped. Except of Singapore, Malaysia, and Thailand, all the other Southeast Asian countries were insignificant partners for high-technology imports in the region.

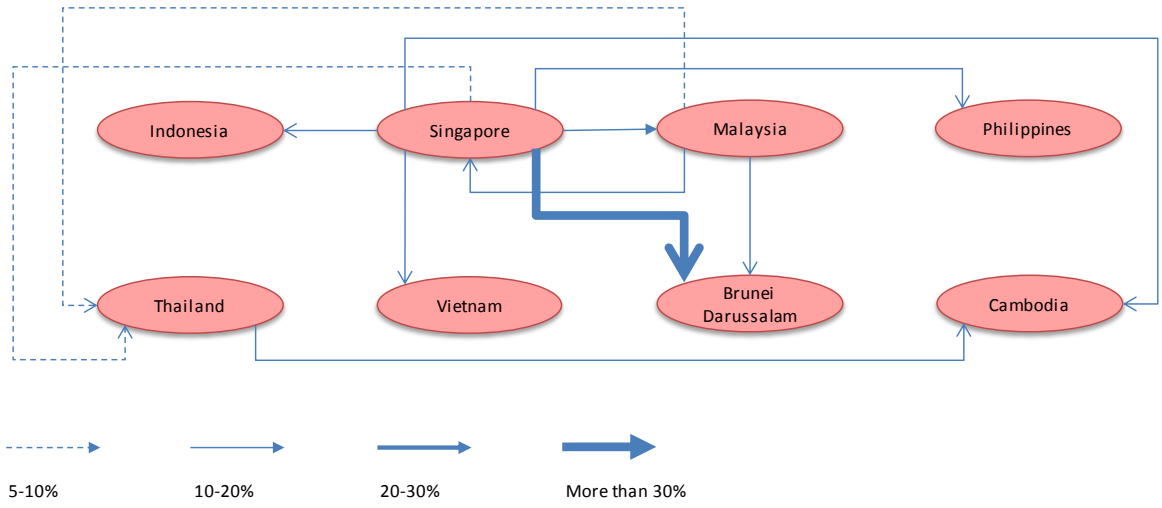
Figure 32: Major trade partners for Southeast Asian high-technology imports in Southeast Asia, 2000



Note: Each arrow indicates that the partner's share of a country's total high-technology imports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Singapore's high-technology imports originate from Malaysia. Data is based on current dollars.

Source: OECD Bilateral Trade Database.

Figure 33: Major trade partners for Southeast Asian high-technology imports in Southeast Asia, 2009



Note: Each arrow indicates that the partner's share of a country's total high-technology imports is equal or greater than 5 per cent. For instance, between 10 and 20 per cent of Singapore's high-technology imports originate from Malaysia. Data is based on current dollars.

Source: OECD Bilateral Trade Database.

87. The preceding developments gave insights into the integration of the Southeast Asian region as an area for science, technology, and innovation. Looking at the disembodied flows of science and technology uncovered the strong scientific linkages among Southeast Asian countries. In these flows,

Malaysia, Thailand, followed by Singapore, are central players. The increasing integration of Southeast Asia as a research area is also corroborated by recent evidence (Haustein, Tunger, Heinrichs and Baelz, 2011). However, the flows of disembodied technology, as measured by international co-inventions, remain limited. They remain driven by Singapore and to a lesser degree by Malaysia. The structure of flows is nevertheless fragmented since few countries participate in the network.

88. Regarding the diffusion of embodied technology, the analysis of intra-trade showed that Singapore and Malaysia were central in the flows of high-technology exports and imports. The central role of these two countries reflects their position in terms of R&D investment in the region. However a substantial share of embodied knowledge flows occurs with the rest of the world.

4.2. Knowledge flows between Southeast Asia and the rest of the world

89. The analysis of disembodied and embodied knowledge flows extends to the linkages between Southeast Asia and a sample of developing and developing countries in the other world regions.

4.2.1. Disembodied knowledge flows

90. International co-publications between Southeast Asian countries and the sample of countries outside the region show strong scientific linkages between the former and Australia, China, Japan, the United Kingdom, and the United States between 2000 and 2004 (Table 13). The involvement of other Asian – principally Korea and India – and European countries was more limited.

Table 12: Number of co-publications between Southeast Asian countries and the rest of the world, 2000-2004

Partner country\ country	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Australia	402	277	154	1135	540	128
China	66	532	166	2335	302	82
Chinese Taipei	24	53	38	305	105	45
Germany	192	105	140	390	221	129
India	42	275	124	307	124	49
Japan	591	352	403	557	1281	316
Korea	34	60	40	151	116	108
New Zealand	26	38	23	173	62	5
United Kingdom	156	431	95	1109	711	181
United States	543	394	573	3072	2080	285

Note: International co-publications counts use simple counts.

Sources: Thomson Reuters, SCI, SSCI, A&HCI, CPCI-S; B. Scheidt, D. Tunger, S. Haustein, and C. Holzke (2010).

91. The scientific network between Southeast Asia and the other countries became stronger and larger during the second half of the last decade (Table 14). In particular, India and Korea played an increasing role as scientific partners for Southeast Asian countries such as Malaysia, Singapore, and Thailand.

Table 13: Number of co-publications between Southeast Asian countries and the rest of the world, 2005-2009

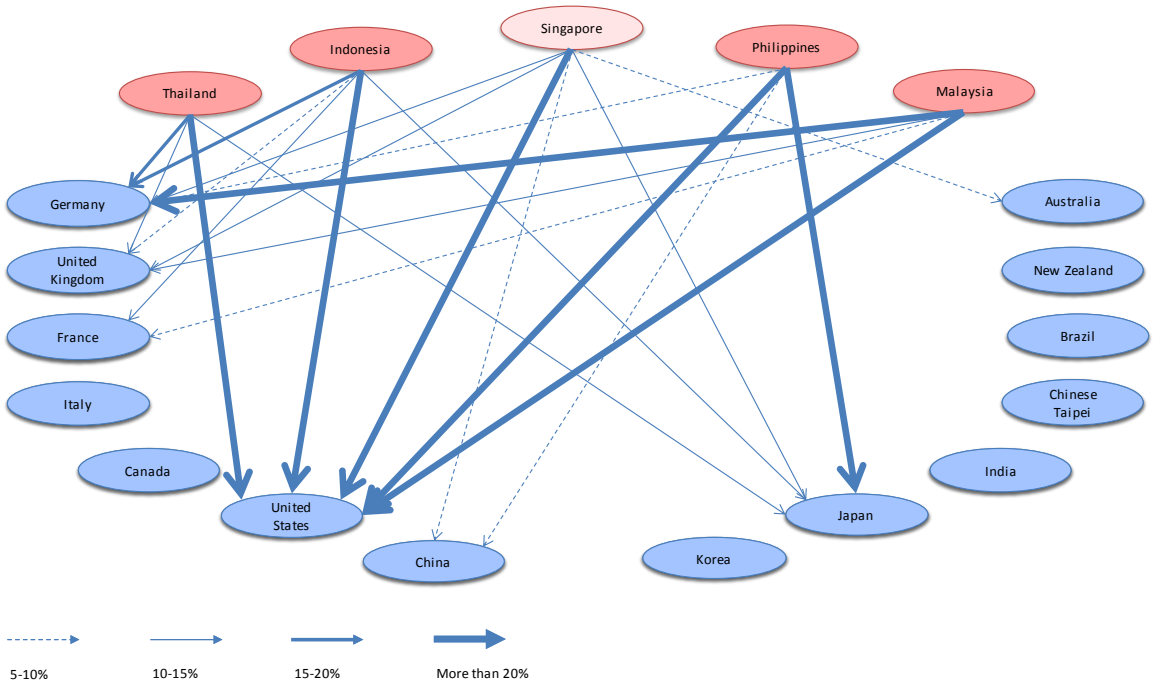
Partner country\ country	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Australia	595	571	314	2120	1178	318
China	170	824	293	5537	847	208
Chinese Taipei	86	151	139	635	280	98
Germany	213	132	119	498	282	139
India	129	852	169	642	329	82
Japan	1039	760	596	981	2483	667
Korea	249	238	153	558	423	415
New Zealand	62	121	37	315	174	19
United Kingdom	154	453	104	1218	859	202
United States	560	431	604	3627	2496	336

Note: International co-publications counts use simple counts.

Sources: Thomson Reuters, SCI, SSCI, A&HCI, CPCI-S; B. Scheidt, D. Tunger, S. Haustein, and C. Holzke (2010).

92. Between 1999 and 2003, international technological co-operation between Southeast Asia and the selected countries outside the region involved mainly the United States, Japan, and European countries, Australia, and Japan (Figure 34). In this international technological network, the United States was a central collaborator for all the Southeast Asian countries. Japan and Germany also occupied a central position, though their ties with the majority of Southeast Asian countries were less strong.

Figure 34: PCT patent applications with co-inventor(s) in selected countries outside Southeast Asia, 1999-2003

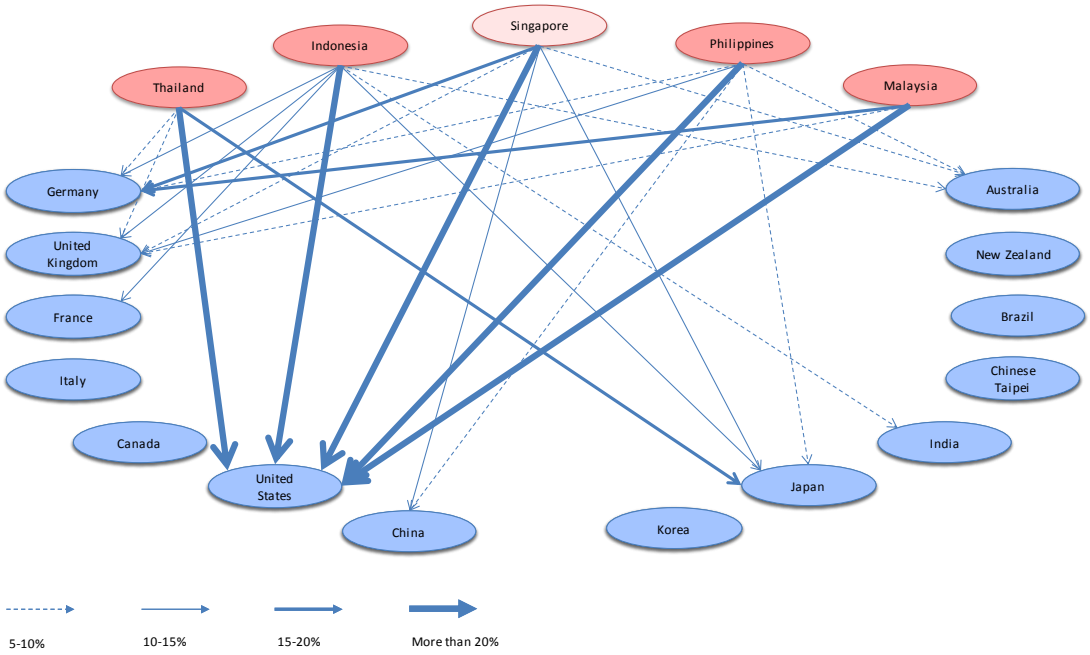


Note: Each arrow indicates that the partner's share of a country's total co-patents with abroad is equal or greater than 5 per cent. For instance, Japan's inventors were involved in more than 20 per cent of total Philippines' PCT patents applications with foreign co-inventors. Patent counts are based on the priority date, the inventor's country of residence and use simple counts on PCT filings at international phase. Only Southeast Asian countries with the highest number of PCT applications over the period are shown.

Source: OECD Patent Database.

93. The structure of the international technological network did not change substantially during the second half of the 2000s (Figure 35). The only notable modification concerns the role of Australia, which became more active as an international technological partner for some Southeast Asian countries such as Indonesia, Singapore, and the Philippines.

Figure 35: PCT patent applications with co-inventor(s) in selected countries outside Southeast Asia, 2004-2008



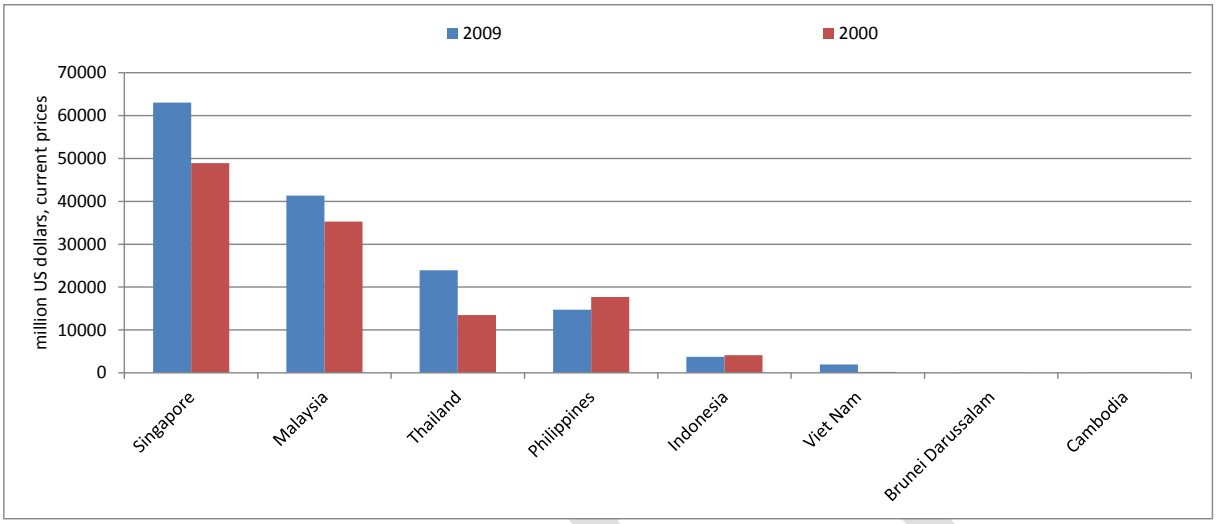
Note: Each arrow indicates that the partner's share of a country's total co-patents with abroad is equal or greater than 5 per cent. For instance, US inventors were involved in more than 20 per cent of total Singapore's PCT patents applications with foreign co-inventors. Patent counts are based on the priority date, the inventor's country of residence and use simple counts on PCT filings at international phase. Only Southeast Asian countries with the highest number of PCT applications over the period are shown.

Source: OECD Patent Database.

4.2.2. Embodied knowledge flows

94. As shown by Figure 36, Singapore and Malaysia were the most important Southeast Asian exporters of high-technology goods to the rest of the world during the past decade. The exports even increased from 2000 to 2009.

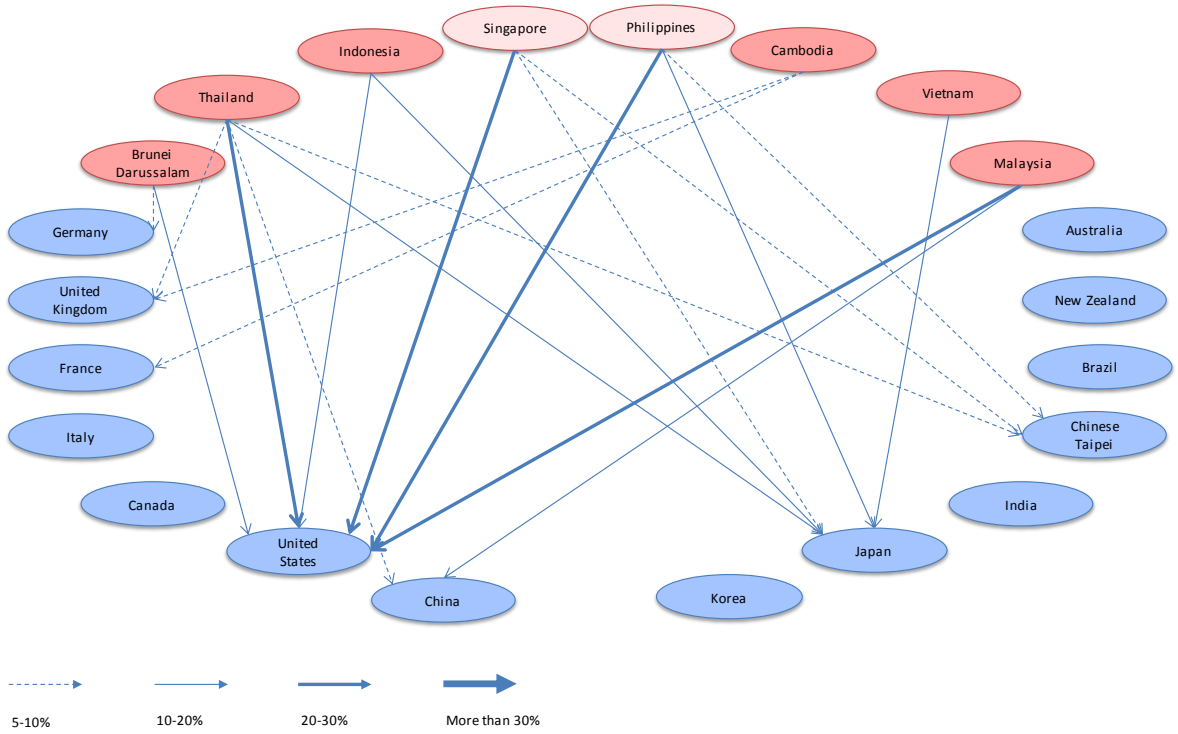
Figure 36: High-technology exports from selected Southeast Asian countries to the rest of the world, 2000 and 2009



Notes: The rest of the world refers to Australia, Canada, France, Germany, Italy, Japan, Korea, New Zealand, the United Kingdom, the United States, Brazil, China, Chinese Taipei, and India

Source: OECD Bilateral Trade Database.

Figure 37: Major trade partners for Southeast Asian high-technology exports outside Southeast Asia, 2000



Note: Each arrow indicates that the partner's share of a country's total high-technology exports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Thailand's high-technology exports are directed towards the United States. Data is based on current dollars.

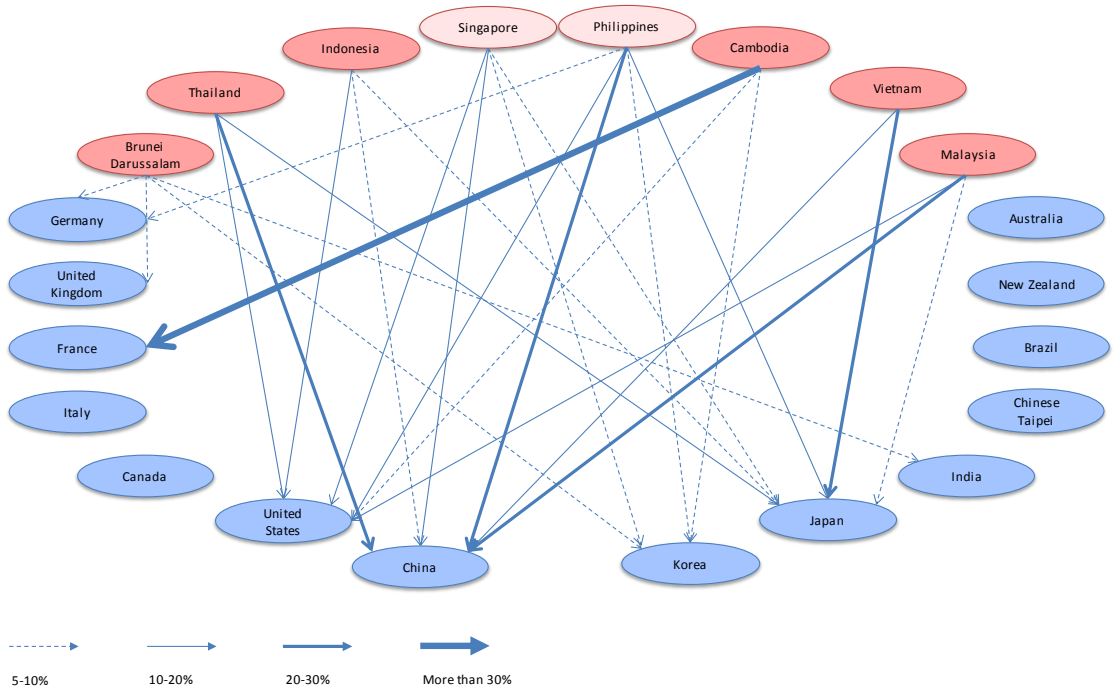
Source: OECD Bilateral Trade Database.

95. Figure 37 shows the flows of high-technology exports from Southeast Asian countries for which data is available to a sample of countries outside the region in 2000.

96. The United States, and to a lesser extent Japan and Chinese Taipei were central partners for all the Southeast Asian countries except for Brunei Darussalam, Cambodia, and Viet Nam. While the share of Japan in Viet Nam's total high-technology exports was 10- 20 per cent, that of the United States and Chinese Taipei was below 5 per cent. Concerning Brunei Darussalam and Cambodia, their high-technology exports to partners outside Southeast Asia were more oriented towards European countries, including Germany, France, and the United Kingdom.

97. The flows of high-technology exports from Southeast Asian countries to the selected countries outside Southeast Asia radically changed in 2009, which the introduction of China as a key market for Southeast Asian high-technology exports (Figure 38).

Figure 38: Major trade partners for Southeast Asian high-technology exports outside Southeast Asia, 2009



Note: Each arrow indicates that the partner's share of a country's total high-technology exports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Thailand's high-technology exports are directed towards China. Data is based on current dollars.

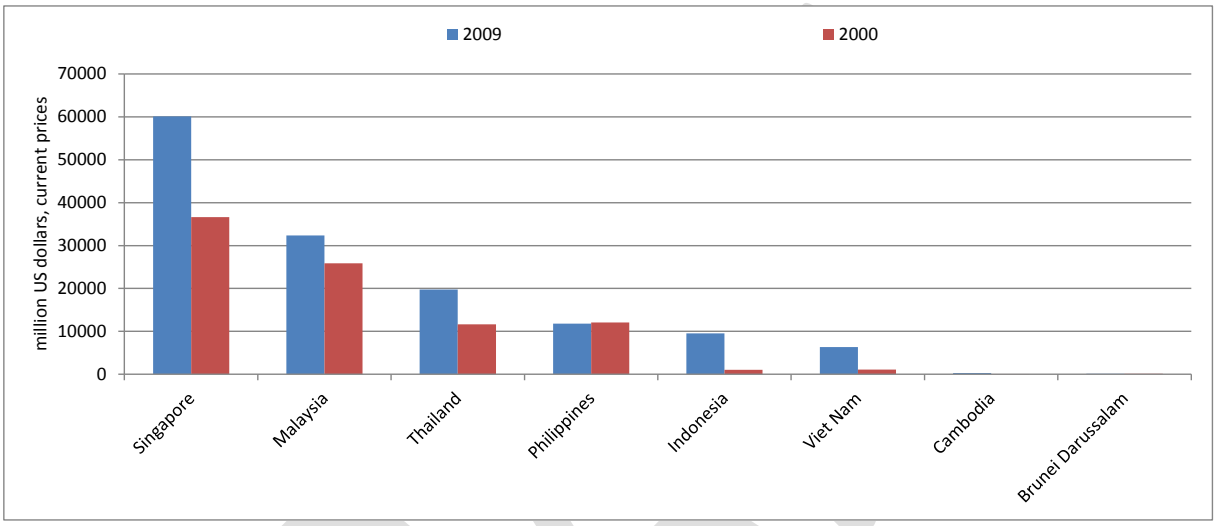
Source: OECD Bilateral Trade Database.

98. The share of the United States in Southeast Asian high-technology exports decreased substantially, though it remained strong. While China was an important market only for Malaysia's and Thailand's high-technology exports, it became a key destination for Thailand's, Philippines', and Malaysia's exports of this category. Its share in the total high-technology exports of these countries totalled between 20 and 30 per cent. China also established itself as an important partner for Singapore, and to a lesser extent Viet Nam and Indonesia. Japan remained a trade partner for several Southeast Asian countries, including Thailand, Indonesia, Singapore, Philippines, and Viet Nam. While its share in Indonesia's high-technology exports declined, it increased with Viet Nam. European countries also maintained trade relations with Brunei Darussalam and Cambodia. Finally, Korea emerged as a market for

high-technology exports from Brunei Darussalam, Singapore, the Philippines, and Cambodia while Chinese Taipei lost its position.

99. An examination of the high-technology imports from the selected countries outside Southeast Asia to a selection of Southeast Asian countries for which data is available reveals that Singapore and Malaysia imported the largest volume of high-technology products in 2000 and 2009. Moreover, their imports increased during that period (Figure 39).

Figure 39: High-technology imports from the rest of the world to selected Southeast Asian countries, 2000 and 2009



Notes: The rest of the world refers to Australia, Canada, France, Germany, Italy, Japan, Korea, New Zealand, the United Kingdom, the United States, Brazil, China, Chinese Taipei, and India

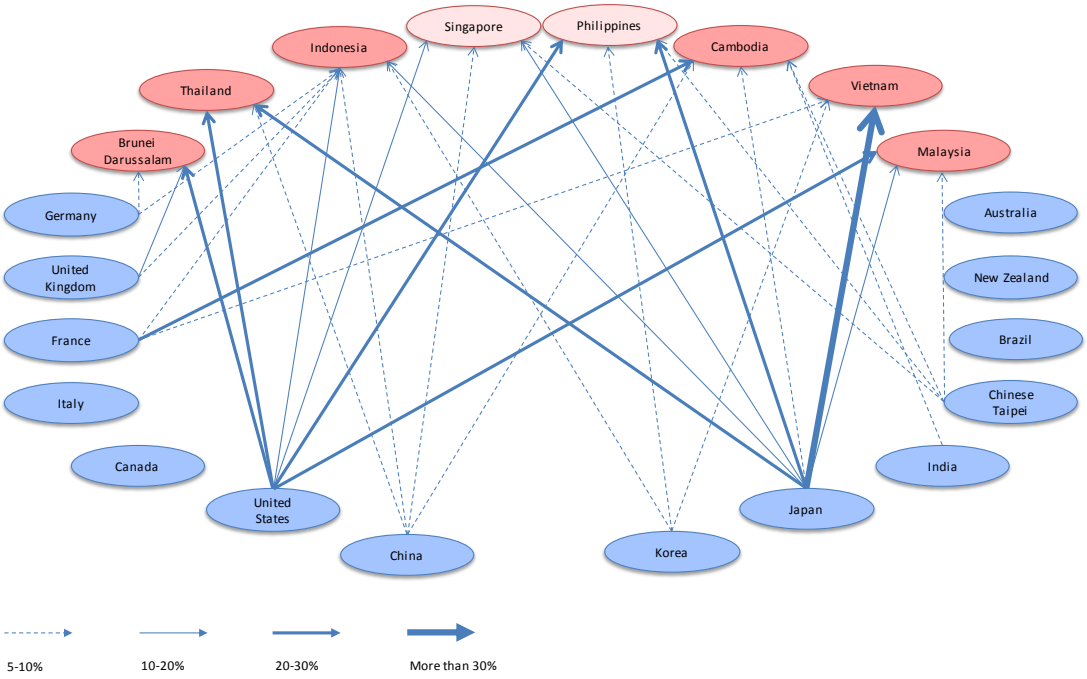
Source: OECD Bilateral Trade Database.

100. Looking at the high-technology imports from the selected countries outside Southeast Asia reveals that the United States and Japan were partners for the majority of Southern Asian countries in 2000 (Figure 40).

101. The share of the United States in the high-technology imports from Brunei Darussalam, Thailand, the Philippines, and Malaysia was 20-30 per cent. It amounted to 10- 20 per cent in the imports from Indonesia and Singapore. The share of Japan in the high-technology imports from Thailand, the Philippines, and Viet Nam totalled 20- 30 per cent. It was 10-20 per cent in Indonesia's, Singapore's, and Malaysia's high-technology imports.

102. In 2009, the structure and strength of the flows of high-technology imports from the selected countries outside the region to the Southeast Asian countries experienced a profound transformation with the rise of China as a high-technology trade partner (Figure 41).

Figure 40: Major trade partners for Southeast Asian high-technology imports outside Southeast Asia, 2000



Note: Each arrow indicates that the partner's share of a country's total high-technology imports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Malaysia's high-technology imports originate from the United States. Data is based on current dollars.

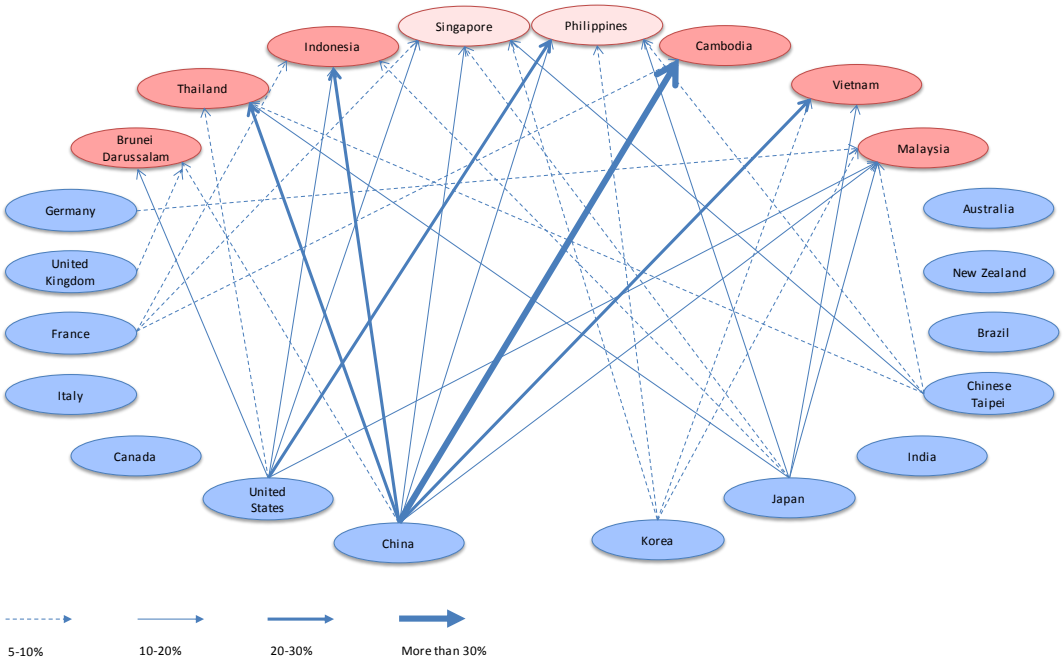
Source: OECD Bilateral Trade Database.

103. The share of Japan and the United States in Southeast Asian high-technology imports declined although these two countries kept strong relations with the majority of Southeast Asian countries. China raised substantially its share in the high-technology imports of all the Southeast Asian countries but Brunei Darussalam. For instance, its share amounted to more than 30 per cent in Cambodian's high-technology imports. It was 20-30 per cent in Thailand's, Indonesia's, and Viet Nam's high-technology imports and between 10-20 per cent in Philippines' and Singapore's ones.

104. The previous paragraphs showed that Southeast Asian countries are increasingly involved in international scientific collaborations with partners outside the region. Singapore and Thailand are core players. The main scientific collaborators of Southeast Asia are the United States, Japan, China, and Australia. Though limited in number, international technological collaboration is performed mainly with the United States, Japan, and Germany. These collaborations nevertheless involve few Southeast Asian countries.

105. Regarding the flows of disembodied technology, there have undergone a substantial change with the emergence of China as a key trade partners for high-technology exports and imports. China has reduced the role of the two traditional partners for Southeast Asian countries, namely the United States and Japan. However the position of these two countries in high-technology trade with Southeast Asia is still important.

Figure 41: Major trade partners for Southeast Asian high-technology imports outside Southeast Asia, 2009



Note: Note: Each arrow indicates that the partner's share of a country's total high-technology imports is equal or greater than 5 per cent. For instance, between 20 and 30 per cent of Indonesia's high-technology imports originate from China. Data is based on current dollars.

Sources: OECD Bilateral Trade Database.

5. Some conclusions

106. Over the past decades, Southeast Asia has enjoyed sustained growth of its output per capita. This growth was notably fuelled by continual improvements in labour productivity and, to a lesser extent, by increased labour utilisation. Southeast Asian countries which have experienced sustained improvements in their standard of living during the past decades have also accumulated physical and human capital at high pace.

107. However, traditional sources of economic growth – such as physical capital accumulation – cannot be relied upon to sustain long-run growth in Southeast Asian countries. Technological progress, spurred by innovation, has to contribute increasingly to the catching-up process. Yet, all Southeast Asian countries but Singapore and to a lesser extent Malaysia, so far have levels of investment in R&D that are low not only compared to those of the advanced economies but also relative to a number of emerging economies.

108. There are a number of factors that tend to be conducive to high levels of investment in R&D. These factors include a well-designed, favourable institutional environment, innovation-friendly financial markets and business environments and a strong human capital base,. Although these factors do not necessarily matter when countries are very far from the world technological frontier, they become critical as countries are moving closer to it.

109. While increased investment in R&D and, more broadly, innovation is required for Southeast Asia to reach higher levels of living standard, this should go hand in hand with a better integration of Southeast

Asian countries in the international flows of scientific and technological knowledge. Such better integration will allow them to benefit from international R&D spillovers.

DRAFT

REFERENCES

Aghion, P. and P. Howitt (2009), *The Economics of Growth*, The MIT Press, Cambridge, MA.

Aghion, P. and P. Howitt (2002), *Endogenous Growth Theory*, The MIT Press, Cambridge, MA.

Asian Productivity Organization (2010), *APO Productivity Databook 2010*, The Asian Productivity Organization, Tokyo.

Barro, R. (1997), *Determinants of Economic Growth: A Cross-Country Empirical Study*, The MIT Press, Cambridge, MA.

Barro, R. and J-W Lee (2010), "A New Data Set of Educational Attainment in the World, 1950-2010", *NBER Working Papers*, No. 15902.

Bosworth, B. and S. Collins (2007), "Accounting for Growth: Comparing China and India", *NBER Working Papers*, No. 12943.

Coe, D. and E. Helpman (1995), "International R&D Spillovers", *European Economic Review*, Vol. 39, pp. 859-887.

Collins, S. and B. Bosworth (1996), Economic Growth in East Asia: Accumulation versus Assimilation", *Brookings Papers on Economic Activity*, Vol. 2, pp. 135-203.

Collins, S. and B. Bosworth (2003), "The Empirics of Growth: An Update", *Brookings Papers on Economic Activity*, Vol. 2, pp. 135-179.

Edquist, C. (ed.) (1997), *Systems of Innovation: Technologies, Institutions and Organisations*, Pinter Publishers, London.

Eichengreen, B., Y. Rhee, and H. Tong (2004), "The Impact of China on the Exports of Other Asian Countries", *NBER Working Papers*, No. 10768.

European Commission (2003), *Raising EU R&D Intensity: Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development*, Report to the European Commission by an Independent Expert Group, Office for Official Publications of the European Communities, Luxembourg.

Fink, C. and E. Maskus (2004), *Intellectual Property and Development: Lessons from Recent Economic Research*, World Bank and Oxford University Press, New York.

Freeman, C. (1988), "Japan: A New National Innovation System?", in Dosi, G., C. Freeman, R. R. Nelson, G. Silverberg and L. Soete (eds.), *Technology and Economy Theory*, Pinter, London.

Eichengreen, B., Y. Rhee, and H. Tong (2004), "The Impact of China on the Exports of Other Asian Countries", *NBER Working Papers*, No. 10768.

European Commission (2003), *Raising EU R&D Intensity: Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development*, Report to the European Commission by an Independent Expert Group, Office for Official Publications of the European Communities, Luxembourg.

Fink, C. and E. Maskus (2004), *Intellectual Property and Development: Lessons from Recent Economic Research*, World Bank and Oxford University Press, New York.

Freeman , C. (1988), "Japan: A new national innovation system?", in Dosi, G., C. Freeman, R. R. Nelson, G. Silverberg, and L. Soete (eds.), *Technology and Economy Theory*, Pinter, London.

Guellec, D. and van B. Pottelsberghe de la Potterie (2001a), "R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries", *OECD Economic Studies*, Vol. 33, pp. 103-125.

Guellec, D. and B. Van Pottelsberghe de la Potterie (2001b), "The Internationalisation of Technology Analysed with Patent Data", Research Policy, Vol. 30, pp. 1253–1266.

Hassan, E., O. Yaqub, and S. Diepeveen (2010), *Intellectual Property and Developing Countries*, The RAND Corporation, Santa Monica, CA.

Haustein, S., D. Tunger, G. Heinrichs and G. Baelz (2011), "Reasons for and Developments in International Scientific Collaboration: Does an Asia-Pacific Research Area Exist from a Bibliometric Point of View?", *Scientometrics*, Vol. 86, pp. 727-746.

INSEAD (2010), *The Global Innovation Index 2009-2010*, INSEAD, Fontainebleau.

Jaumotte, F. and N. Pain (2005a), "An Overview of Public Policies to Support Innovation", *OECD Economic Department Working Papers*, No. 456.

Jaumotte, F. and N. Pain (2005b), "From Ideas to Development: The Determinants of R&D and Patenting", *OECD Economic Department Working Papers*, No. 457.

Keller, W. (2010), "International Trade, Foreign Direct Investment, and Technology Spillovers", in B. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, Vol. 2, pp. 793-829, North-Holland, Amsterdam.

Kim, J-I. and L. Lau (1996), "The Sources of Asian Pacific Economic Growth", *The Canadian Journal of Economics*, Vol. 29, Special Issue: Part 2, pp. S448-S454.

Koopman, R., Z .Wang, and S-J Wei (2008), "How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-Added When Processing Trade is Pervasive", *NBER Working Papers*, No. 14109.

Krugman, P. (1994), "The Myth of Asia's Miracle", *Foreign Affairs*, Vol. 73, pp. 62-78

Iwata, S., M. Khan, and H. Murao (2002), "Sources of Economic Growth in East Asia: A Nonparametric Assessment, *IMF Working Papers*, WP/02/13.

Lall, S. and M. Albaladejo (2004), "China's Competitive Performance: A Threat to East Asian Manufactured Exports?, *World Development*, Vol. 32, pp. 1441-1466.

Lau, L. and J. Park (2003), *The Sources of East Asian Economic Growth Revisited*, Mimeo.

DRAFT

Lee, G. (2006), "The Effectiveness of International Knowledge Spillover Channels", *European Economic Review*, Vol. 50, pp. 2075–2088.

Lundvall, B-A. (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, Pinter, London.

Nelson, R. (1993), *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press.

Nelson, R. and H. Park (1999), The Asian Miracle and Modern Growth Theory", *Economic Journal*, Vol. 109, pp. 416-436.

OECD (1999), *Managing National Innovation Systems*, OECD, Paris.

OECD (2002), *Dynamising National Innovation Systems*, OECD, Paris.

OECD (2010a), *OECD Science, Technology and Industry Outlook 2010*, OECD, Paris.

OECD (2010b), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, OECD, Paris.

OECD (2010c), *Southeast Asian Economic Outlook*, OECD, Paris.

Page, J. (1994), "The East Asian Miracle: Four Lessons for Development Policy", *NBER Macroeconomics Annual*, Vol. 9, pp. 219-269.

Park, J. (2010), "Projection of Long-term Total Factor Productivity Growth for 12 Asian Economies", *ADB Economics Working Paper Series*, No. 227.

Park, W. (2008), "International Patent Protection: 1960-2005", *Research Policy*, Vol. 37, pp. 761-766

Rodrik, D. (1995), "Getting Interventions Right: How South Korea and Taiwan Grew Rich", *Economic Policy*, Vol. 20, pp. 55-107.

Sarel, M. (1997), "Growth and Productivity in ASEAN Countries", *IMF Working Papers*, WP/97/97.

Senhadji, A. (2000), "Sources of Economic Growth: An Extensive Growth Accounting Exercise", *IMF Working Papers*, WP/99/77.

Scheidt, B., D. Tunger, S. Haustein and C. Holzke (2010), *Bibliometric Analysis Asia-Pacific Research Area 2010*, Report commissioned by the International Bureau of BMBF at DLR.

Stiglitz, J. (1996), "Some Lessons from the East Asian Miracle", *World Bank Research Observer*, Vol. 11, pp. 151–177.

Young, A. (1995), "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience", *Quarterly Journal of Economics*, Vol. 110, pp. 641-680.

Vandenbussche, J., P. Aghion and C. Meghir (2006), Growth, "Distance to Frontier and Composition of Human Capital", *Journal of Economic Growth*, Vol. 11, pp. 97-127.

Van Pottelsberghe de la Potterie, B. and F. Lichtenberg (2001), "Does Foreign Direct Investment Transfer Technology Across Borders?", *Review of Economics and Statistics*, Vol. 83, pp. 490-497.

DRAFT

Wattanapruttipaisan, T. (2007), "Priority Integration Sectors in ASEAN: Supply-side Implications and Options", *Asian Development Review*. Manila: 2007. Vol. 24, pp. 64-89.

World Bank (1993), *The East Asian Miracle: Economic Growth and Public Policy*, The World Bank, Washington D.C.

DRAFT