WHAT IS BEHIND ASIAN R&D SPENDING GROWTH?

The business sector is the main spender of R&D in all GR7 nations. This does not diminish the importance of governments as drivers of R&D trends. Public investment in science and technology is, when successful, an enabler of subsequent R&D performance within the private sector. And the state influence in private companies can be substantial.

&D

Table 1 shows the share of total R&D expenditure financed by the public sector. Perhaps contrary to expectations, Asia has a lower share of R&D funding accounted for by the government than the US and Europe. About 75 percent of Japan's total national R&D came from the business sector. For Korea it is 73 percent, and for China 72 percent. In contrast, in the United Kingdom (33 percent), Germany (28 percent), and United States (31 percent) the share of state financing in R&D is high. France has the largest public share among GR7 countries (39 percent).

The common conjecture that Asian R&D is mostly government funded (or performed) is thus not confirmed by the data. That of course does not preclude the importance of government influence in instigating private R&D. Many of China's large private companies are state controlled or influenced.

GR7 governments differ significantly in what they spend their R&D budgets on, reflecting different government R&D priorities (eg, defense, health, general non-directed research) Comparable data for China is unfortunately not available.

Defense has been for much of the past quarter century, and continues to be, the focus of more than half of the US federal R&D budget. France also spends more than one quarter of its public R&D budget on defense. Within the non-defense federal US R&D budget, health has expanded dramatically and accounted for in 2009 more than a quarter of the federal R&D budget. Japan is the country with the highest government outlays on energy R&D. South Korea concentrates its biggest share on industrial technology. The ‘other’ category includes general funding to universities, which is typically non-targeted.

Overall the data does not support the notion that the rise of Asia in R&D is driven by direct government spending. It does show however a different profile of sectors targeted by government-funded R&D. And it does not exclude government influence in private sector R&D, particularly in China.

WHICH SECTORS ARE DRIVING ASIAN R&D GROWTH?

Because businesses account for the largest share of total R&D spending in most countries, differences in business structure go a long way to help explain international differences in trends in R&D-to-GDP ratios. Countries that specialise in dynamic high-tech sectors (such as pharmaceuticals and ICT) are more likely to also have higher and increasing R&D-to-GDP ratios than countries in which the business structure is weighted more heavily towards slower growing low- or medium-tech industries. Europe's failure to increase its R&D-to-GDP ratio is often attributed to its failure to specialise in high-tech sectors (see for example previous Bruegel Policy Briefs: Van Pottelsberghe, 2008, and Veugelers and Cincera, 2010).

Compared to the US, which has a broad spread across sectors, smaller economies in Asia show much higher concentrations of R&D spending in particular industries. For example, in South Korea, the ICT industry, which includes semiconductors, accounted for 64 percent of the country's business R&D spend. The share of ICT spending in Singapore and Taiwan is similarly big. The rise of the Asian R&D tigers therefore correlates with the industrial focus on R&D in the ICT sector.

A significant trend within the growth in US business R&D spending has been the growth of spending by the service sector, accounting for 32 percent of all business R&D expenditure in 2009 (14 percent for computer-related services). Services also account for about one quarter of all private R&D spending in the UK. In Asia, the services sector is still less predominant in business R&D, representing 11 percent or less of spending in Japan, China and South Korea.

DOES THE GROWTH IN ASIAN R&D SPENDING TRANSLATE INTO GROWTH IN ASIAN INVENTIONS?

How efficient is the new Asian R&D investment? Is it resulting in a new generation of inventions and sources of growth?

Patents are regarded as a good proxy for innovation, despite a wide-ranging debate on whether they encourage or hinder innovation (eg Harhoff, Scherer and Vogel, 2003). Given the requirements for a valid patent (novelty, utility and non-obviousness) they are an important step as inventions progress towards commercialisation. In addition, their licensing may provide an important source of revenue. However, not all inventions are patented. The propensity to patent varies by industry and technology area. In addition, patents suffer from a 'truncation' problem, with the most recent trends not available, in view of the time it takes to process patent applications. The patent data source that suffers least from the time lag issue is Patent Cooperation Treaty (PCT) applications[2].

In line with the rise in global R&D expenditure, total PCT applications have been rising continuously (6 percent average annual growth rate, 1999-2009). But within this overall rise in patenting, there are significant regional differences (Figure 3 on the next page). The dominant position of the US in patenting is gradually eroding. While the EU has been able to match, and even slightly outpace, the US in patenting, it is, like the US, gradually ceding share to Asia. Among Asian countries, Japan is the most important patenting country, and has consistently increased its share of PCT applications. The rise of China is, like R&D expenditure, clear to see, albeit from a very low level. Perhaps most notable in terms of patenting growth is South Korea, which produces, despite its smaller size, a similar number of patents to China.

Table 3 compares the trends in countries' share of global patents relative to R&D. A ratio greater than 1 (ie the country has a greater share of world

2. The Patent Cooperation Treaty (PCT) provides a framework for filing patent applications to protect innovations in each signatory country. The PCT offers the possibility to seek patent rights in a large number of countries by filing a single international application with a single patent office (receiving office). Applicants have an additional 18 months to decide whether to seek a national or regional (eg European Patent Office) patent; if they so wish, they must do so within 30 months of the priority date (an average of 60 percent of PCT filings enter the EPO regional phase). The PCT procedure is increasingly used for patent applications, strongly correlated with an increasing number of contracting states.

Industry	France 2007	Germany 2008	Japan 2009	S. Korea 2008	UK 2008	US 2009	China 2009	Singapore 2009	Taiwan 2009
Pharma	14.3	7.4	10	2.4	27.2	15.9			

specific high- or low-quality bias. China's position however is markedly different. The rise of China is much less evident when triadic patents are considered, compared to the growth rate in overall patenting in China. This indicates that growth in the production of Chinese inventions does not so far have a strong international orientation.

WHICH TECHNOLOGIES ARE DRIVING THE ASIAN PATENT GROWTH?

The opportunities for technological innovation and hence new patent applications vary substantially across technologies. The 'hottest' areas with the greatest scope for new technology developments include biotechnology, ICT, nanotechnology and clean energy. The dynamic patent performance of countries – whether they increase or not their share of global patents – will depend to a great extent on how strong they are in these technology growth areas.

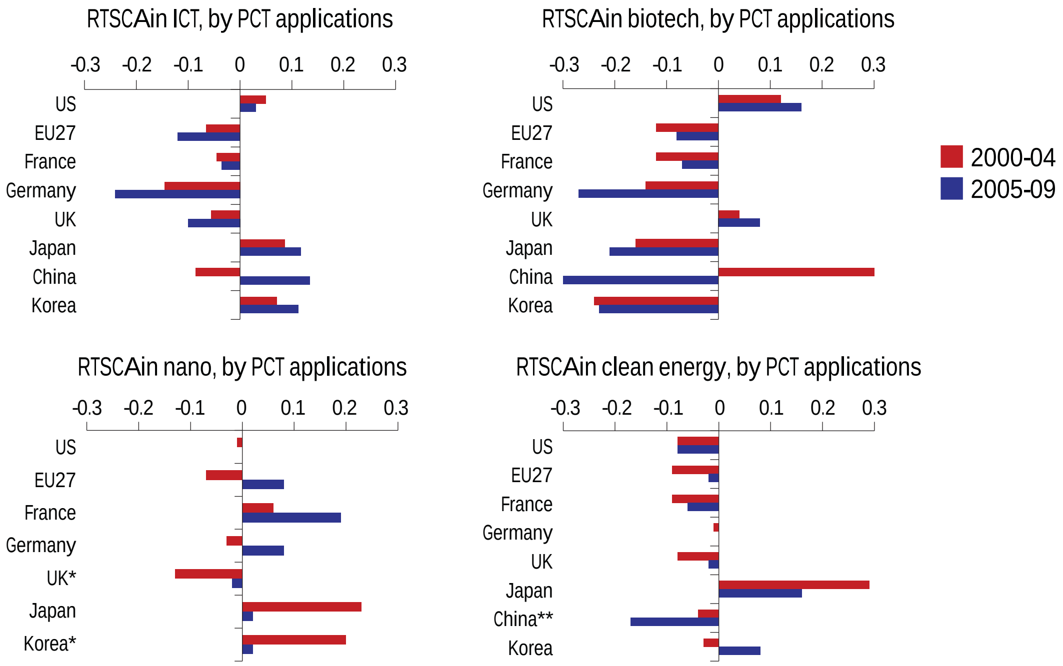
The EU27 as an aggregate does not specialise in any of the selected growth areas, with the recent exception of nanotechnology, in which Germany and France are building up a technology strength. The UK specialises in biotechnology. In clean energy, the EU does not yet hold a technology advantage, although it is making progress. Particular attention should be paid to the weak and deteriorating position of the EU in ICT.

It is in ICT in particular that Asia is building up its technology strength. This holds for Japan, South Korea and China, and correlates with the concentration of R&D investment in these countries in this area, and their science focus on engineering, physics and chemistry (Veugelers, 2011). Confronted by this rising Asian ICT power, the US remains strong in ICT, though its position is eroding.

In the other selected growth areas, the rise of Asia is less clear-cut. Biotech is a clear US strength, and is not an Asian relative stronghold. Nanotechnology is still very much early stage and volatile in terms of technology specialisation patterns. In clean energy, Japan has a strong hold, although this is gradually eroding, while South Korea is building up a strong position in this field.

Although China has ambitions in all technology growth areas, for the moment, it is only in ICT

Figure 5: Trends in specialisation in selected technology growth areas by major regions, revealed symmetric technology comparative advantage index (RSTCA), 2000-09



Source: OECD. Note: for a description of the RSTCA calculations, see Annex 1. * fewer than 250 patents in both periods; ** fewe than 250 patents during 2005-09. RSTCA in the nano sector for China has not been included because the number of patents during the period is too small for a reliable estimate of the indicator.

be 59 percent, while for Japan, the EU15 and the US, it is more than 75 percent.

This correction for foreign content holds particularly for high-tech goods, because global value chains are prevalent in high tech sectors such as ICT, and much of the value of final products is embedded in components and design.

Table 5 shows the foreign value added shares in gross exports for high tech goods. It shows that: i) high-tech exports have a high share of imported content, particularly in China and Korea (column 3); ii) for most countries the foreign value added intensity is much higher in high-tech goods than for the overall economy (column 4). This is particularly the case for China; iii) the foreign share in high tech has been increasing over time for most countries (columns 2-3), but especially in China (no data for 1995 available for Korea).

All this suggests that the rise of China and to a lesser extent Korea in high-tech exports and the declining shares for the US, Europe and Japan, need to be properly adjusted for the role these countries play in international value chains of high-tech goods, particularly ICT. The case of Apple's iPad is illustrative (see Annex 3). China, which merely assembles and then exports the final product is credited with the full value of the factory price (plus shipping costs) in gross trade statistics, but its domestic value added, being mainly an assembler, is tiny and hence its contribution is much smaller than other countries which supply inputs and manufacture components.

	% of foreign value added in gross exports of high-tech goods (1995)	% of foreign value added in gross exports of high-tech goods (2005)	% of foreign value added in high-tech goods relative to all goods (2005)
China	20.1	48.5	1.77
Korea		46.3	1.21
Japan	10.0	21.5	1.41
US	16.6	17.4	1.62
France	29.1	29.2	

Properly factoring in China's role as the assembler of high-tech goods and crediting exports to countries on the basis of their domestic value added contribution would reduce the trade deficit that many countries have with China[5], particularly those countries which design and produce high-value components. At the same time, China and other south-east Asian countries also manufacture components for high tech goods that are assembled elsewhere. In this case, these countries' value added is attributed elsewhere. IMF (2011) analysis shows how the growth of high-tech exports from the US, EU15 and Japan was almost entirely driven by growth in foreign value added and how significant China's contribution has been, through the manufacturing of intermediate components, to the growth of these countries's high-tech exports. All this signals the significance of global value chains, with major impacts on countries' trade structures, blurring the analysis of export data for assessing competitiveness. What matters is where value added is created and where it is captured. On this, the case of the Apple iPad makes clear the critical role of who holds key property rights, and controls design and marketing. In the iPad case the US still captures the major part of the value added, although it has almost entirely outsourced the manufacturing, retaining only a small manufacturing base producing critical components. The value captured by the US is mostly related to design and marketing.

MAIN FINDINGS

A previous Bruegel publication, ('A G2 for science', Policy Brief 2011/03), concluded firmly that China is on the rise as a science powerhouse. Although other countries, such as South Korea, are also catching up, the Chinese emergence in science is uniquely rapid, particularly in engineering, chemistry and physics. 'A G2 for science?' also documented a China-US connection which is virtuous, mutually beneficially, so far robust and more or less unique, predicting a future science landscape that will look more like a G2 than a truly multipolar system, with the attendant risk that Europe and other countries will be sidelined. Can we extend this prediction into an emerging G2 for innovation as well?

The evidence presented in this Policy Contribution clearly shows that there is an increase in Asian R&D investment. As in science, China is now the second R&D spender, after the US, bypassing Japan. Although the EU as a bloc spends more than China, China has already the combined size of Germany, France and Italy. Although China's rise is again very robust and rapid, and is likely to continue, in common with China's science growth, other south-east Asian countries are also rapidly increasing their R&D spends. This holds most notably for Korea, while Japan is an incumbent R&D stronghold and India is lagging. Most new Asian R&D investment, even if it comes mainly from the private sector, is backed by targeted public support.

This growth in Asian R&D investment is translating into increasing patent filings. In fact, Asian countries have grown even faster in patenting than in R&D investment. But although the increase in China's share of world patent applications has risen faster than its share in world R&D expenditure, it is still only a minor player in patent terms, with the same impact as much smaller Korea. And when looking at the most valuable inventions, ie those for which patent protection in sought in all major world markets, China's share remains tiny. This Asian growth in R&D spending and patents is very much focused on ICT, an area with high technological opportunities and positive externalities acting on other sectors. In other technologies with high growth potential, such as clean technologies and nanotechnology, the global playing field remains open. World markets for pharmaceuticals remain as dominated by the EU and US.

When looking at the economic value created by innovative new goods and services, all of the countries with major R&D expenditure are increasingly concentrating their economic activities in knowledge intensive goods and services. In this respect, the US is the most specialised and China the least, with the EU inbetween. Furthermore,

oster than its 82e EU inbet0031 Tisice-2Tph Tj T.01 T76(vice-2TT n a2Tphf rfaster t-,In03 theal, 5ods andw